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SOME OBSERVATORIES AND OBSERVERS, PAST AND PRESENT.

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The purpose for which we are assembled today directs our attention to the oldest and noblest of the sciences, as it is sometimes called, and to the methods and appliances which have at one time or another been developed for its cultivation and further extension. On the one hand it is true that we may trace backward the history of our science until its early beginnings are lost in the mists and shadows of prehistoric antiquity, while on the other, when we compare all that has been accomplished towards unravelling the mysteries of the universe with the infinitely great unknown, we must feel that the science of astronomy is even now in its infancy.

An astronomical observatory is an institution which doubtless inspires the average man with much respect. Here he sees a building of peculiar construction, containing a telescope of more or less imposing dimensions. Here the astronomer is supposed to pass his nights, predicting the weather or otherwise inquiring into the secrets of nature.

It has occurred to me that it might not be unprofitable today to look somewhat into the history and evolution of astronomical observatories, and to glance briefly over the careers of a few of those who have been instrumental in developing the science of astronomy as we have it now.

The earliest astronomical observations of which we have any knowledge called for no observatory as we understand the term. No telescopes or instruments of precision existed. All that was required was an unobstructed view of the heavens, and careful attention on the part of the observer. It is to the Chaldeans and Egyptians that we are chiefly indebted for these early beginnings. Their priests appear to have given these matters their very careful attention. Eclipses and the movements of the planets claimed their especial notice. The grouping of the stars into

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constellations, and such data as could be gathered from watching their times of rising and setting were subjects of earnest study. In Egypt particularly the connection of the heliacal rising, as it is called, of Sirius with the overflow of the Nile was for thousands of years an object of attention on the part of the priests.

The accuracy with which the pyramids are placed with respect to the points of the compass, together with other details of their construction gives some plausibility to the hypothesis that they were designed with the view to some kind of astronomical observation. In other words, that we may look upon them as astronomical observatories, built thousands of years ago. Probably, however, such observation as took place here had to do, simply with the correct orientation of the structure, and was designed for no more scientific purpose.

It is to the Greeks, and particularly to Hipparchus, 150 years before Christ, that we are indebted for the first successful effort to form a science of astronomy. The perfection of this science, and the possibility of future prediction of the positions of the Sun, Moon and planets, and of the occurrence of eclipses called for the construction of instruments and for a higher degree of precision in observation.

The first astronomical observatory of which we have any knowledge was established by Ptolemy Sotor in connection with the famous Academy at Alexandria. The descriptions which have come down to us of the instruments and methods in use here are in some respects provokingly meagre, but we are doubtless quite safe in assuming that they represented the very best which the science and skill of that day could produce. At all events with the aid of observations made here and at Rhodes by Hipparchus, astronomical science was so far perfected that very little improvement was made during the next 1500 years.

With the decline and fall of the Roman Empire took place a corresponding decline and fall in scientific activity. Such learning as survived found refuge in the monasteries. But little respect was found for heathen science which was placed in the same category with the religion of heathenism. Much, if not all, of the ground already gained by the Greeks would probably have been lost but for the services rendered by the Mohammedan conquerors. We find the Arabian Khalips and the Mongol Khans assembling learned men at their courts irrespective of religious creeds and building observatories on a scale of magnitude never before thought of, at Bagdad, at Mokattan, at Samarkand, and

elsewhere. Perhaps the most ambitious of these was that constructed by the astronomer Nassir Ed din at Meragha North West Persia, A. D. 1260. Here were brought together all of the scientific books which could be found throughout the empire. The most noted astronomers were assembled and buildings and instruments were constructed regardless of expense. So much prodigality finally alarmed the monarch, but we are told that he was persuaded to go on with the enterprise by representations showing the great profit which might be expected from the investment. In fact, the most potent arguments advanced in those days for the cultivation of astronomy were found in the fact that the tables of Ptolemy had become so unreliable that the predictions of the astrologers could no longer be depended on.

The Greeks produced comparatively few observers but many philosophers. It better suited their genius to evolve systems from their own brain, often without much reference to the facts of nature. The Arabs, on the other hand, appear to have had a taste for observation but were able to make but little use of the data so obtained.

In astronomy, though they made some improvements in detail, they were afraid to wander far from the beaten path. They added little to the science as developed by Hipparchus and Ptolemy a thousand years before their time; but the great service which they rendered and for which we owe them a debt of gratitude, consisted in preserving the science from extinction until such time as a more progressive people were ready to take hold of it and carry it to the degree of advancement where we find it today.

With the advent of that indefinite period called the renaissance we find observatories appearing in various places, chiefly in Germany, at first. The most celebrated of these and the one where more was accomplished towards advancing astronomical science than anywhere else was the celebrated Uraniburg of Tycho Brahe.

Tycho's interest in astronomy was aroused by an eclipse of the Sun which occurred when he was a lad of fourteen. The fact that it took place at the time predicted made a profound impression on his mind. His pocket money went for the purchase of books and instruments, and, instead of giving his energies to the study of law as he was supposed to do, he passed his nights in studying the heavens. After various wanderings and adventures in the course of which he lost his nose in a duel, and incurred the hostility of his family by marrying the daughter of a peasant, he ultimately found favor with King Frederick II of Denmark. That

monarch conferred upon Tycho a liberal income, and gave him as a site for his observatory the island of Hveen not far from Copenhagen. Here was laid the first stone of the structure, August 8, 1576, and here was brought to the highest degree of perfection then attainable the instruments and methods of exact astronomy.

These methods were essentially those practiced by the Greeks 1600 years earlier. Many improvements in detail were introduced and new forms of instruments devised. Thanks to the skill of the mechanicians who constructed the instruments and that of the observers who employed them, a degree of precision was reached never before attained. Of equal importance was the close application to the routine duty of observation, which led to the accumulation of a mass of material of the utmost importance to the future development of the science.

On the death of his patron, Tycho, for some reason found himself out of favor at court. His income was stopped and having expended the greater part of his private fortune in his astronomical enterprises he was compelled to leave Denmark. This was on the whole, fortunate for astronomy, for Tycho was thus brought in contact with Kepler, then a young man. To what extent Kepler's enthusiasm for astronomy was due to Tycho's influence is uncertain. However this may be, Kepler's protracted investigation which resulted in his three famous laws could hardly have been brought to a successful issue without the fine series of observations of the planets which thus came into his possession.

These laws again formed a starting point for Sir Isaac Newton's epoch, making researches by which the law of universal gravitation was established. Possibly the genius of Newton might have triumphed over all obstacles, even if Kepler had never lived, but the task would have been much greater.

Tycho found another royal patron in the person of the emperor Rudolph II, but his life soon after terminated at the comparatively early age of fifty-five.

Unlike Hipparchus or Copernicus or Kepler or Newton, the name of Tycho Brahe is not associated with any great epoch-making discovery. He proposed a somewhat absurd system to explain the planetary motions, which apparently no one took very seriously. Tycho's contribution to astronomical science was that of a careful painstaking, conscientious observer.

Philosophers may find great satisfaction in evolving from their inner consciousness elaborate systems of creation. Like Descar-

tes they may consider it of small importance to show how the universe is made unless they can show to their own satisfaction that it could not have been made otherwise, but science is not advanced by any such process. We must endeavor to find out what are the facts, and then by induction determine if possible, the underlying principles and laws.

All exact astronomy must have for its basis an accumulation of carefully observed facts. Usually this is not the kind of work which brings its votaries into popular notice. But the workman who lays deep and sure the foundation of a palace performs quite as important a service as the artist who designs the statue to adorn its topmost pinnacle.

Seventy-five years after the time of which we have been speaking Denmark produced another of those great men whose activity in the field of observational astronomy was destined to make a lasting impression on the future of the science.

Roemer was born at Aarhuus, Jutland, September 21, 1644, died at Copenhagen, September 23, 1710. He was therefore a contemporary of Newton.

Roemer's name is more commonly associated with his great discovery of the fact that light requires a measurable time to make its journey through space.

Uraniburg the scene of Tycho's activities had disappeared from the Earth. After Tycho's departure the peasants had pulled down the buildings and carried away the stones for use elsewhere. Only the foundations remained to mark the spot where Tycho had passed the most important part of his life, and where he had left the greater part of his private fortune. For the purpose of accurately locating this place before the disappearance of its last traces, Picard the illustrious French astronomer made the journey to Denmark in 1671. Roemer, then 27 years of age, assisted in this work and at its conclusion accompanied Picard to Paris, where he remained for nine years. It was during this period, that Roemer, while engaged in studying the motions of Jupiter's satellites, noticed the peculiarity which led to his great discovery. It was found that when the Earth was in that part of its orbit which brought it nearest to Jupiter, the eclipse occurred earlier than the time predicted, while the opposite was the case when the planet was farthest from us. Roemer's explanation of this phenomenon was the true one, viz., that the light from the planet having farther to travel in the latter case, required a longer time for its journey. This explanation appeared altogether too radical a departure from accepted ideas and it

was rejected by most of Roemer's contemporaries. Newton and Huyghens seem to have been almost the only ones to accept it. It was necessary that Bradley, fifty years later, should rediscover it under a totally different aspect before it found general acceptance.

It was in 1681 that Roemer returned to Copenhagen. After Tycho's departure, an observatory had been built in the city. This was a wooden tower 115 feet in height. The observing rooms at the top were reached by means of a spiral avenue winding around the interior. It is related that on various occasions Peter the Great of Russia rode to the top of the tower on horseback and even that the Empress Katherine occasionally made the journey in a four wheeled chariot drawn by six horses.

We may very well believe that Roemer found this structure poorly adapted to his form of instruments, and that he found it necessary to remove first to a room in his private house. Afterwards an observatory was built under his direction outside the city on lines in accordance with modern ideas.

This was a period of transition from methods and instruments which had come down from the days of Hipparchus to those in use today. The invention of the telescope, of the pendulum clock, of the vernier and the micrometer, produced a revolution in the astronomy of precision, and we find Roemer and his former patron, Picard, occupying places in the front rank of this movement. The instruments erected by Roemer in his new observatory were in all essential respects the equatorial, the transit circle, and the prime vertical of today.

To attempt mentioning all of the observatories which have contributed to the advancement of astronomical science, would give this discourse the character merely of a dry catalogue of names and dates. Before considering more particularly the development of astronomy in our own country, there are, however three of the great observatories of Europe which call for at least a passing notice. The origin and history of the observatories of Paris, Greenwich, and Pulkova are in each case characteristic of the age and country to which these institutions belong.

The beginnings of this Paris Observatory furnish an admirable illustration of Dickens' phrase, "how not to do it." In Grant's History of Physical Astronomy we read, "The Royal Observatory of Paris was commenced in 1667 but was not finished until 1671. It was a building of great magnificence designed by Claude Perrault, the famous architect of the Louvre, but it was constructed without due regard to the purpose for which it was

intended. It consisted of a quadrangular pile flanked by two massive towers. No means were provided for enabling the astronomer to observe the celestial bodies at all altitudes nor was it possible to repair the omission on account of the enormous thickness of the walls." Dominique Cassine who had arrived in France in the year 1669 commenced his labors at the Observatory on the 14th of September 1671. It is important to remark however, that no special duties were assigned to him in connection with that establishment, nor did he derive any emoluments from the French government in consideration of his services as an astronomical observer. His superintendence of the Royal Academy was naturally suggested by the position which he occupied as first astronomer of France, but his duties were altogether discretionary. The consequence was that no definite plan of observation was projected, by the undeviating adherence to which the advantages of a national observatory can alone be realized.

In short, a monumental building was erected without any reference to the requirements of observation and the services of a brilliant scientist were secured, but who unfortunately was by no means abreast of the times in what pertained to practical astronomy. It is probably well within the truth to say that one fourth of the money here lavished merely in show and ornament, expended under the direction of Picard might have produced four times as valuable results in the way of furthering astronomical science.

The early history of the Greenwich Observatory forms a striking contrast to the above. The problem of determining the longitude at sea was at this period one of great importance. Large rewards had been offered by various governments for its practical solution.

In 1675 a Frenchman who called himself LeSeur de St. Pierre claimed to be in possession of a practical method easy of application, and applied to the English government for the promised reward. His method was the process now well understood, of employing the distance of the Moon from one or more stars. The matter was referred to a committee of which Flamsteed was a member, and whose opinion as an expert naturally decided the action to be taken. Flamsteed reported that in the condition of the science at that time the method was not available, as the computed place of the Moon was sometimes as much as 12′ in error and the positions of the fixed stars were not known closer than 5′ or 6′. A longitude so determined might therefore be in

error by some hundreds of miles. The matter was brought to the attention of the King, Charles II, and for once at least, that worthless monarch gave his attention to serious matters long enough to perform an act which has been of the greatest benefit to his country and the world. June 2, 1675 a royal warrant for building an Observatory was issued "in order to the finding out of the longitude, for perfecting navigation and astronomy." Flamsteed was appointed Astronomer Royal with the princely salary of £100 per year. This was subject to a tax of £10, and lest time should hang heavily, it was required that the astronomer should instruct two boys from Christ Church Hospital. With corresponding prodigality the sum of £500 was appropriated for building the Observatory. Besides this, the King allowed bricks from Tilbury Fort and some wood, iron and lead from a gate house demolished in the Tower. No instruments were provided for, and nothing in the way of assistance except what Flamsteed calls a "surley laborer." We can very well believe Flamsteed's statement that he earned his salary by labor harder than thrashing.

This was the humble beginning of that institution which has contributed more than any other to the progress of exact astronomy during the past 200 years.

Like the Paris Observatory, that of Pulkova was built and equipped regardless of expense, by an autocrat. Here, however, the similarity of the two cases comes to an end. At Pulkova the matter was entrusted to one of the ablest and most accomplished astronomers then living, William Struve. Every effort was made to secure the best and most accurate instruments which science and skill could produce. When these were ready for service they were placed in charge of an able corps of astronomers, with results which have more than justified the wisdom of the imperial founder and of the successive directors.

The Greenwich Observatory has grown up from small beginnings, while that of Pulkova may be said to have been made to order. Each has been, and is now, a credit to the nation to which it belongs.

The beginnings of physical science in America have been compared to the birth of Minerva, as she sprang fully armed from the brain of Jove. The simultaneous appearance in Philadelphia of Franklin, Rittenhouse, and William Smith, men who were entitled to a place among the world's leaders, at once brought this country to the notice of the scientists of England and France.

It is true that astronomy had not been entirely neglected before

the advent of Rittenhouse. In 1740 we find John Winthrop of Harvard College observing a transit of Mercury and publishing his results in the *Philosophical Transactions.* Again, in 1761, Winthrop was sent at public expense to Newfoundland, for the purpose of observing the transit of Venus. In 1769 Winthrop had another opportunity to observe this phenomenon; but it was in Philadelphia, the home of the three distinguished men above mentioned, and where the Philosophical Society furnished a basis for organized effort that the greatest interest was aroused in this approaching event. The transit in question was due on the 3d of June, 1769, and as an opportunity would then be offered for a solution of the important problem of the Sun's distance, an opportunity not to be had again for a period of 105 years, it was regarded as of the utmost importance that this one should be made the most of.

In August 1768, ten months before the transit, Rittenhouse and Smith were appointed by the Philosophical Society members of a committee to provide for its observation. A temporary Observatory was built near the residence of Rittenhouse at Norristown for this purpose. We shall not be far wrong in saying that this was the first Observatory, temporary or otherwise, erected in this country.

Extensive preparations were made for insuring success. Observers were stationed at three points as a precaution against local failure. At Norristown, twenty miles from Philadelphia, the home of Rittenhouse, the observers were Dr. William Smith, Provost of the College of Philadelphia, David Rittenhouse, and John Lukens, Surveyor General of Pennsylvania. At the State House Square, Philadelphia, observations were taken by John Ewing, Joseph Shippen, Dr. Williamson, James Pearson and Charles Thompson. At Cape Henlopen the observers were Owen Biddle, Joel Bailey, and Richard Thomas.

Every precaution was taken to insure success and we may well believe the accounts which have come down to us of the breathless anxiety with which the observers awaited an event which had been seen on only two previous occasions, and we may add has only been seen twice since that day.

What may be called the secondary results of this transit appeared likely to be of much more importance for this country than the immediate object in view. I refer to the great interest in astronomy then awakened. This at one time seemed in a fair way to take the tangible form of a permanent, well equipped Observatory with Rittenhouse at its head. But, alas, the mut-

terings of the coming Revolution soon foretold the storm in the presence of which all other interests were forgotten. It was many years after the return of peace before we again find anything approaching the interest in astronomy here described.

Rittenhouse appears to have enjoyed the highest appreciation of his contemporaries. Thus we find Jefferson saying, "We have supposed Mr. Rittenhouse second to no astronomer living; that in genius he must be the first, because he is self-taught. As an artist he has exhibited as great proof of mechanical genius as the world has ever produced. He has not indeed made a world, but he has by imitation approached nearer its Maker than any man who has lived from the creation to this day."

In the poem entitled the "Vision of Columbus" written in 1787 by Joel Barlow are found these lines:

"See the Sage Rittenhouse, with ardent eye,
Lift the long tube and pierce the starry sky;
Clear in his view the circling systems roll,
And broader splendors gild the central pole.
He marks what laws th' eccentric wand'rers bind,
Copies Creation in his forming mind,
And bids, beneath his hand, in semblance rise,
With mimic orbs, the labors of the skies,
There wandering crowds with raptured eye behold
The spangled heav'ns their mystic maze unfold;
While each glad sage his splendid hall shall grace,
With all the spheres that cleave th' eternal space."

The closing lines of both quotations refer to a remarkable planetarium constructed by Rittenhouse which in that day appears to have created more enthusiasm than all his other achievements combined.

More than seventy years elapsed before our country witnessed another revival of interest in this science. Individual efforts were not wanting but with the passing away of the individual the movement ended. At the centers of advanced education, Harvard, Yale, Columbia, Pennsylvania, and so on, through the list, by no means a short one, there appears to have been very little interest in astronomy or any branch of natural science.

In 1832 the first College Observatory in the United States was built at the University of North Carolina by Dr. Joseph Caldwell president of the institution. As a pioneer effort, this first member of a long and distinguished line claims more than a passing mention.

The building, we are informed, was a brick structure, 25 feet square and the same in height. The instruments were a refract-

ing telescope, a meridian transit, a zenith telescope, an astronomical clock, sextant, reflecting circle, and Hadley's quadrant. These were purchased by President Caldwell in London in 1824. The building for accommodating them was completed in 1832. Here was an encouraging outlook; and we are told that observations were carried on for a number of years by President Caldwell himself, by Professor Elisha Mitchell and Professor James Phillips. No records of these observations are now known to exist.

The sequel is somewhat depressing. Dr. Caldwell died in 1835. The Observatory was partially destroyed by fire in 1838. For some reason the instruments had been previously removed. The bricks were used by Dr. Caldwell's successor for building a kitchen. It is at least comforting to know that this is still in use or was fifteen years ago when the account to which I am indebted was written. At the same time it is said that the ruins of the Observatory were then plainly visible on a hill just outside the campus.

It is related that when Sherman's troops had possession of the town soldiers found the dusty old telescope reposing on an upper shelf in one of the lecture rooms. Having a taste for astronomy probably, they brought it out of its resting place, when they had the satisfaction of discovering that some of the professors had chosen the tube as a hiding place for their gold watches. Evidently experience had indicated that nowhere was there less probability of discovery; but here, as in a number of instances, the Yankee mind was found to act in a manner somewhat different from that of his southern brother.

About the time when the brief career of this pioneer Observatory ended, a more successful attempt in this direction was made at Williams College. Here was formally dedicated June 12, 1838, 65 years ago, the first Observatory in the United States destined to become a permanent institution. This was built by Albert Hopkins, brother of the more widely known Mark Hopkins, mainly at his own expense and to some extent with his own hands. Although there is another Observatory at Williams College, I understand that this ancient structure is still in use.

It may not be out of place to say here that at this time some of the greatest of European astronomers were at the zenith of their activity, Bessel, Struve, Gaus, Encke, Argelander.

In this country the work of the coast survey was creating a demand for astronomical training, but for many years Congress resolutely opposed the establishment of a government Observa-

tory. Appropriations for the survey were made with the proviso that no part of the funds should be used for this purpose. Jefferson was very earnest in pressing the matter upon the Congress. When in 1829 the bequest of James Smithson came to hand there was a considerable movement to employ the funds or a part of them in founding an Observatory; but all these efforts came to naught. Finally, a bill was passed, not for an Observatory, but for a depot of charts and instruments. Thus the National Observatory was compelled to disguise itself and to assume another name before it could obtain the congressional support.

But the one agency which was more potent than any other or possibly than all others combined, in re-arousing public interest in astronomy was found in the precept and example of one man, Ormsby McKnight Mitchell. A graduate of West Point, a lawyer, a college professor, a civil engineer, a major-general of volunteers during the Civil War.

In 1834, Mitchell, then a young man of 24, was elected professor of mathematics, philosophy, and astronomy of the newly established Cincinnati College. In 1842 he undertook a task for which very few at that time could have found the courage and perhaps no one besides himself could have brought to a successful issue. This was nothing less than the erection of a first-class Observatory at Cincinnati.

To quote Mitchell's own words, "In attempting to communicate the great truths of astronomy, there were no instruments at hand to confirm and fix the wonderful facts recorded in the books. Up to that period, our country, and the west particularly, had given but little attention to practical astronomy. A few individuals with a zeal and ardor deserving of all praise, had struggled on to eminence, almost without means or instruments. An isolated telescope was found here and there scattered through the country; but no regularly organized Observatory with powerful instruments existed within the limits of the United States so far as I know."

Mitchell's account of his struggles reads like a romance. All kinds of difficulties were encountered, and in some way overcome. When other means failed for going on with the necessary buildings, he advanced the money himself, though not possessing a great share of this world's goods. Finally, to quote Mitchell's own words: "In February 1845 the great telescope safely reached the city of Cincinnati, and in March the building was ready for its reception. I had now exhausted all my private

means, and to increase the difficulty of the position in which I was placed, the college edifice took fire and burned to the ground. My ordinary means of support were thus destroyed at a single blow. I had engaged to conduct the Observatory without compensation from the Society for ten years, in the hope that my college salary would be sufficient for my wants. It was impossible to abandon the Observatory. The college could not be rebuilt, at least for several years, and in this emergency I found it necessary to seek some means of support, least inconsistent with my duties at the Observatory."

As a solution of this difficult problem Mitchell became a public lecturer. In the words of one of his friends and admirers, "More than any other man in America has he thus accomplished for his favorite science. Besides the Observatory he founded, and the instruments he imported, and to which he has greatly added by his improvements and inventions, he awakened in thousands of minds an interest in the subject, instructed popular assemblies not only by his clear outlines of the gigantic science but by his masterly handling of its difficult and abstruse theories and problems and by his fiery words which exhibited his own knowledge and enthusiasm, told of its divine beauties and relations, and kept crowded audiences all over the country in breathless and delighted attention."

The revival of astronomical interest in America may be said to date from this time. During the following years, which preceded the outbreak of the Civil War, the great questions of slavery and secession were ever present. Nevertheless time and energy were found for other things. We see observatories springing up at Cambridge, New Haven, Albany, Philadelphia, Ann Arbor, and everywhere a growing interest in astronomical science.

This was the period of what may be called the older school of American Astronomy. Many of the distinguished men of that day are no longer with us. A few are still in active service. Among the former we may mention Pierce, Chauvenet, Gould, Hubbard, Brunnow, Watson. This by no means completes the list.

Again the course of history brings to our view a group of embattled farmers. Their leader now is John Brown. Again is fired a shot destined to be heard round the world. We are here on historical ground. The memories of the days of those preliminary encounters which ushered in the terrible struggle are still fresh in the minds of some of us. The excitement, the sacrifices, the anguish which filled the land, both north and south,

were not calculated to encourage the advancement of abstract science. But though the impetus which had been given to astronomy was doubtless checked and its progress retarded, events have abundantly proved that the check was temporary only. At no time, or in any country has the advance been so rapid, as with us during the past forty years. Never before have such princely endowments been devoted to the furtherance of education and scientific inquiry. Were we to enter into details we could hardly avoid extending this discourse far beyond the time at our disposal.

We are present here today for the purpose of welcoming this latest addition to the list of American observatories. Its existence, I am told, is due to the generosity of an unnamed benefactor. We may perhaps sympathize with and respect the feeling of the giver in preferring to remain unknown. Nevertheless, it would be a satisfaction to ourselves could we offer him personally our thanks today.

While there are lines of research in which an Observatory like this one will not attempt to compete with such astronomical establishments as those found at Cambridge, at Mt. Hamilton, or at Williams Bay, yet the instruments now here and those in view are capable of doing most valuable work in furthering our knowledge of the skies. It is of interest to know that the principal instrument here is the same in size as the "great telescope" mounted at Cincinnati by Mitchell, and that the mechanism and appointments of this Observatory are vastly superior to the earlier one. In fact, when Mitchell built the Cincinnati Observatory there seem to have been only three or four refracting telescopes in existence larger than this one. But the primary and most important end to be accomplished here, I apprehend, is in introducing to the young men and women who from year to year assemble here, such knowledge of the wonders of the skies as can only be had by viewing them with their own eyes, and with their own hands directing the necessary instruments. We are told that "The proper study of Mankind is Man." It is certainly a line of study which points to innumerable warnings and pitfalls. The origin, the development and the destiny of our race certainly present us with problems of great interest and importance.

"He who through vast immensity can pierce,
See worlds on worlds compose one universe,
Observe how system into system runs,
What other planets circle other suns,
What varied beings people every star,
May tell why Heaven has made us what we are."

For the astronomer the greatest of all problems, and the one which may be said to include all others, is that of determining the structure and mechanism of the universe. This citadel can not be carried by assault as the deductive philosophers used fondly to imagine. Possibly its solution lies beyond the reach of our feeble powers. Every advance made seems only to give us more exalted ideas of the magnitude, the complexity, the variety of nature's works. Each problem solved, each truth discovered, adds to our store, though we may be only the more convinced of our own insignificance. We, however, know that

> "All are but parts of one stupendous whole,
> Whose body Nature is and God the Soul."

STAR DUST.

DANIEL E. WING.

For Popular Astronomy.

The study of nebulæ is a subject to which much attention is given by astronomers who have the management of or access to large telescopes, for doubtless these difficult objects possess the key to knowledge on our part of the laws governing the arrangement and distribution of matter in the process of sun making and world making, which rightly understood will enable us to comprehend the manner in which systems are evolved, the significance of the physical changes they undergo as bearing upon the ultimate form which matter assumes, and finally to arrive at some intelligible conclusion as to what may be such ultimate form.

The law of evolution as applied to matter in the universe at large may be stated briefly as follows:

(1). The condensation of matter accompanied by the dissipation of force (heat), followed by (2) The development of force accompanied by, or occasioning, the dissipation of matter.

It will be noted that these are reverse processes, the first being that which seems to be best demonstrated by the so-called nebular hypothesis.

Areas of gas, in diffused nebulous form, are visible; also nebulæ in various stages of condensation. Evidence of spiral motion is plainly discernible in many nebulæ and such motion is believed to exist in all. It is impossible to conceive matter in a state of rest. Obeying the law of gravitation the particles tend to press toward the point of greatest condensation. Centers of attrac-

tion form, with a swirling motion like a whirlpool. The momentum of rotation is increased by the fall of particles which are unable to reach the center. Acting under its own gravity the mass becomes more and more condensed. Every motion of each particle develops heat which the combined mass radiates. The outermost part or circumference eventually reaches a stage where it can no longer adhere. Separation takes place, the inner mass further condensing to leave behind new rings. Condensation of rings and nebula proceeds.

So much for theory. Do the observed facts lend aid for its substantiation?

Over eight thousand objects are catalogued as nebulæ under the following forms: Annular (including elliptical, which are probably annular nebulæ seen edgewise), spiral, planetary, irregular nebulae and nebulous stars. Many of these objects, catalogued as nebulae, have been resolved into star clusters with present optical aids, and it was formerly believed that all were so resolvable, but the spectroscope proves the contrary to be the fact. Nearly all the annular, planetary and irregular nebulae give the gaseous spectrum. Photography has shown vortical motion to exist in many of the fainter objects, which it is needless to say the eye was unable to detect; in fact by this means fields of nebulous matter are shown to cover vast areas of the heavens where before its existence was not suspected. Centers of condensation appear in a great number of nebulae. This feature is very pronounced in the great spiral in Canes Venatici. Two well known centers are visible in small instruments while powerful ones show the convolutions of the spiral to be dotted with condensations. The great nebula in Andromeda is apparently composed of several rings, showing knots of condensing nebulosity. Nebulous stars exhibit completely condensed centers enveloped in fields of luminous gas frequently showing the ring formation. The Magellanic clouds, lying toward the south pole of the heavens, show the transformation of gaseous matter in every degree of condensation from barely discernible nebulous light up to discrete stars and star clusters.

So then we have visible proof of star making from matter acted upon by known laws. We also know that these distant suns radiate heat from condensation like our Sun; the quantity that reaches us is measurable. That there is a limit to the process of condensation is obvious. When the body has parted with all its heat, when there is no longer any motion among its particles, it will cease to condense. Is it thereafter forever doomed to

wander in lifeless space? If so, we have reached the ultimate form of matter for the lapse of sufficient time is all that is necessary to bring every body in the universe to the same state.

Is this the end—matter having actual existence but without force; force existing potentially? We believe not. Death is the forerunner of new life in every form of matter. Dissolution is but a process effecting change of form. It is at this stage that we apply, theoretically, the reverse process of that outlined, dissipation of matter to the gaseous form brought about by the passage of this potential force into actual force. Is there any evidence that such process will become operant in the solar system? No. Long periods of time are requisite to furnish facts upon which to predicate a reliable opinion with respect to the truth or falsity of such theory from actual observation. It is believed, however, that the planets must in the course of thousands of years show the effects of a supposed resisting medium in space which must tend to gradually slow down their orbital motions. The truth of this belief once established, the end of the planets is in sight; they must eventually fall into the Sun. It matters not when that event happens or from what distance the fall occurs. Certain it is that sufficient force (heat) would be developed by such a collision to reduce their solid contents to gas and to scatter such gas into the most attenuated nebulosity.

Does the universe afford any evidence that collisions of such character do occur? If this process of redistribution of matter is the outcome of a general law, presumably sufficient time has elapsed for it to occur since the world's attention was invited to the consideration of this theory. The reasonable interpretation of observed facts can alone furnish the answer to this inquiry. From the profound depths of star space, say a thousand trillion miles distant, comes to us the evidences of natural phenomena that seem to satisfy all the conditions incident to the evolution of new life from old. At intervals of more or less frequency, sometimes in successive years, there occurs an outburst in the heavens with swiftness only rivalled by the telegraphic intelligence conveyed to the world: "A new star in Auriga;" "a new star in Perseus;" "a new star in Gemini." Nine such occurrences have happened in the last fourteen years. Let us see if we can intelligibly grasp what this message from space signifies. At a point in the heavens where no trace of a star was previously visible some watchful eye discovers a star. In a few hours it increases several magnitudes in brightness, for example the new star of 1901 increased two and a half magnitudes in forty-eight

hours, that is to say its visible brightness increased tenfold in that short time. The human intellect utterly fails to realize what this means. Such an outburst on the part of the Sun might vaporize all the planets; it is reasonable to suppose that it would at least melt the Earth's crust. The spectrum of a new star exhibits matter in motion at tremendous velocities to and from us, 600 to 1000 miles per second. In 1901 the same peculiarities showed that were new to astronomers in 1892, to-wit the appearances were as if a solid body moving rapidly in one direction collided with or plunged into a nebulous mass moving as swiftly in the opposite direction. Following this sudden outburst of brightness there is a fading out during a period of months and change to the nebulous form of matter becomes apparent. Photographs at this stage show annular or spiral formation, and the latest triumph in photography is to show the existence of spiral motion in the nebula which succeeded the new star of 1901. Comparison of photographs taken two or three months apart show perceptible change by reason of motion and evidence that the process of condensation has set in.

Here, then, we have appearances best accounted for by the collision of matter, occasioning development of force resulting in redistribution of matter, to again take up the initial process of condensation through spiral motion.

Belief in this never ending process, whereby youthful vigor is acquired, seems better to fulfill the laws governing matter and force than the supposition that the universe is destined to become a graveyard and space to be ultimately filled with the corpses of extinct suns and planets.

NEW YORK, October 1, 1903.

A REMARKABLE PHENOMENON.

REV. FREDERICK CAMPBELL, D. Sc.

FOR POPULAR ASTRONOMY.

During the late evening of August 21st last, the writer, in company with several others, witnessed a celestial phenomenon surpassing in wonder anything that ever before had come to their attention. I was spending three weeks at Cranberry Lake, St. Lawrence Co., N. Y., in the Adirondack wilderness. The latitude of this place is about 44 degrees and 12 minutes north, and the longitude 74 degrees and 45 minutes west. It is about 75 miles nearly east of the city of Watertown, N. Y.

When the Sun had set, the northern sky seemed remarkably bright; and, as the darkness deepened, it was apparent that the illumination was something more than that of evening twilight. We were being treated to a display of aurora borealis, or northern lights. The spectacle was more marked than is often seen even during winter nights. There were streamers that reached far beyond the Great Dipper; and occasionally, in the midst of the general radiance, certain spots would brighten to an intense glow and again fade somewhat. There was no color at any point, simply the clear pure light. But the glory was enhanced by occasional flashes of lightning near the northern horizon, but unaccompanied by thunder.

We gazed upon this with interest for some time, and then retired within doors and gave it very little more thought. At about half past nine, however, I was suddenly summoned out of doors to witness a spectacle such as I had never looked upon before nor had ever heard or read of. The heavens were spanned by two great bows of light, crossing each other near the zenith by a wide angle. The one was the familiar Milky Way or Galaxy, then in its glory, no Moon being present. The other was a remarkable archway of light, comparable with the Galaxy in width, but much brighter, and seemingly, stretching from horizon to horizon, though in the one direction its light, like that of the stars, faded near the horizon, and in the other it was obscured by a small cloudbank. I estimated the width of the arch to be three degrees or that of six full moons placed side by side. This bow stretched from a little north of west, to a little south of east. It passed just south of Arcturus in the west, and just north of Jupiter in the east, at 10:00 P. M. The arch remained in place for a long time, possibly half an hour or more. It changed very little in appearance and brilliancy. In places it had a fluted, wavy aspect, being completely broken only here and there, and then only by a very narrow interval. The waves appeared as if gently blowing in the direction of the arch, toward the northwest, like curtains waving in a breeze, or a little like steam being blown along. As the wind was actually blowing very freshly at the time, the illusion was not difficult. The entire arch was bright, and where brightest easily obscured all the stars in the immediate vicinity. Job's Coffin and Altair were in the arch.

The first thought was that this was a great streamer of the aurora borealis, seen earlier in the evening, and still continuing quite brightly; but it was apparent at a glance that it was some-

thing totally distinct; for one thing, it arched the entire heavens; again, it did not narrow to a point, but was equally broad across the entire sky; but most of all, it did not radiate from the north at all; it extended from a point nearer west than north, somewhere between northwest and west. Moreover, the next day I conversed with two reliable men who were together out-of-doors when the spectacle started up; and of them I learned that it did not originate at its more northerly or northwest extremity, but at its southeast end. They saw it rise from that direction and gradually extend itself along the sky in a generally northwest direction until the heavens were arched as when I first saw the sight. It seems altogether probable that the simultaneous appearance of the aurora borealis and of this archway of light indicates a common origin, even if the arch could not be regarded as a part or a streamer of the aurora. Evidently there was a wide-spread magnetic disturbance of the atmosphere which caused the aurora to appear first, and later threw this great bow across the sky. But why it should have manifested itself in this way, choosing its direction and regulating its width as it did, is a very great mystery. Something a little similar to this I recall seeing in the same part of the country several years ago, repeated two or three evenings; but at that time there was no arch, but a strange and persistent brightening of the heavens in a northwest direction, well up, and entirely detached from the horizon, with no accompanying aurora, as far as I now recall.

There was no possibility of this being a lunar rainbow, for there was no color, and there was no Moon. Borrelly's comet was near at the time, but there was no possibility of this being its tail, and doubt as to the comet's being in any way responsible.

Department of Astronomy,
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SUGGESTED EXPLANATION OF THE PHENOMENON OBSERVED BY REV. CAMPBELL.

M. A. VEEDER.

For Popular Astronomy.

The phenomenon described by Mr. Campbell was undoubtedly auroral, although lacking certain characteristics commonly supposed to be essential to the existence of the aurora. According to accepted ideas the luminous band observed, if of the nature of an auroral arch, should have had the magnetic pole of the Earth

as its center, and should have been arranged perpendicularly to a line drawn from the observer toward that pole, or on the other hand, the band if of the nature of a streamer, should itself have pointed directly toward the magnetic pole. As far as can be determined from the description given neither of these conditions were fulfilled in the case under consideration, and furthermore the writer has observed such to be the fact in connection with many other displays of the aurora. This being the case accepted ideas in regard to the relation of the aurora to the magnetic pole of the Earth may need considerable modification.

The fact is that the solar electro-magnetic field developed during displays of the aurora, in the form of what is known as a magnetic storm, needs to be taken into account. In other words in connection with such storms there is a concentration of effect in a direction from the Sun determined by the position of the lines of force emanating, as they do in a perfectly definite way, from disturbed portions of its surface. Thus in addition to the permanent magnetic pole of the Earth there is developed a very temporary and rapidly changing magnetic pole due to direct impulses from the Sun; and it is the combined effect of the solar and terrestrial poles that determines the arrangement of auroral arches, streamers, bands and masses of luminosity. Perhaps the commonest evidence of this, seen in this part of the United States, is to be found in connection with displays of the aurora during the early hours of the evening. In such cases there is as a rule a grouping and origination of the brightest parts of the aurora east of the geographical meridian of the place of observation, whereas in this locality the magnetic pole is west of the meridian instead of eastward where such concentration of effect is observed. Many observers, who were entirely unskilled in such matters, called attention to this at the time when concerted observations of the aurora were being made in connection with the Peary expedition. It was as if a force playing upon the Earth from the direction of the Sun were displacing the auroral phenomenon of various kinds eastward, the effect being most marked near the equinoxes, and early in the evening, it disappearing toward midnight. Other similar effects explicable in this manner were noted in reports from other parts of the world, the distortion of distribution relative to the position of the terrestrial magnetic pole varying at different hours of the night and at different seasons of the year, in a manner consistent with the explanation given.

Another point that comes out very clearly in connection with

such study of the aurora, at the time of the Peary expedition, that has since proved to be of great practical importance, is the evidence of tangency of the electro-magnetic inductive effects both to Sun and Earth. Forces of this kind do not pass off, or exercise their chief effect, along lines vertical to the surface on which they may originate. They travel along, and around such surfaces, in other words tangentially and not radially. This is the principle involved in the Marconi system of telegraphy. Were it otherwise it would be impossible to send messages hundreds of miles along the surface of the Earth from points at an elevation of a few feet. Thus clear evidence has been obtained that electro-magnetic inductive effects originated upon disturbed portions of the Sun do not pass off radially but exercise their chief effect along lines tangent to its surface. In like manner when such impulses fall upon the Earth their chief effect is distributed along lines of tangency, the absolute maximum being at that part of the surface of the Earth at which such impulses are most constantly tangent, that is at the Arctic and Antarctic circles, resulting eventually in the formation of the permanent magnetic poles at that latitude.

It is evident that the play of such forces tangent to Sun and Earth, and presumably other planetary bodies, might very well account for motions of rotation, a point in physical astronomy for which there has thus far been no explanation whatever.

From considerations such as these it has seemed to the writer that observations such as that recorded by Mr. Campbell are well worthy of careful study. It is a question of the identification of the forces in operation, which to many minds appears to be pure theory, but it is not, it is the real thing.

LYONS, N. Y., Oct. 5th, 1903.

REVIEW OF SOLAR OBSERVATIONS FOR THE YEAR 1902 AT ALTA, IOWA.

DAVID E. HADDEN.

FOR POPULAR ASTRONOMY.

The following solar observations made here during the year 1902 are in continuation of those contributed to POPULAR ASTRONOMY, No. 97, for August-September 1902.

As explained in POPULAR ASTRONOMY No. 95 only a brief résumé is attempted, the detailed daily results have been sent regularly to the director of the solar section of the British As-

tronomical Association. The instrument used was a 4-inch Brashear refractor.

There was a noticeable revival of solar activity during the year 1902; compared with the preceding year the number of spotless days had decreased nearly 8 per cent and the average number of groups had increased about 50 per cent, indicating that the minimum epoch had been passed in the year 1901 and the new cycle of solar activity had commenced.

January: A fair-sized and rather interesting group was present during the first half of this month in low south latitude, it apparently formed, attained its greatest size and activity and declined during its transit on the visible disc, as it did not reappear at any subsequent rotation—an expiring member of the old cycle. The last half of the month was spotless.

February: This month was absolutely quiescent,—not a spot or faculæ to mar the perfect tranquillity of the brilliant photosphere.

March: The first half of the present month brought one of the largest groups of the year, which appeared in high north latitude and belonged to the new cycle; it contained several umbræ, some of which were bridged, but owing to some repairs being made to the Observatory dome, the group was not followed attentively. The return of the region of disturbance of this group at the east limb on the 30th, consisting only of bright faculæ was coincident with an unusual display of the aurora—a description of which I published in POPULAR ASTRONOMY, May 1902. A period of perfect tranquillity set in on March 14th which continued until May 22d during which time no spots and but few faculæ were visible.

May: On the 23d a group appeared which during its transit across the disc, assumed the normal phase; this group was probably a recurrence of the March disturbance.

June-September: This prolonged period extending over four solar rotations was almost entirely devoid of spots. On September 18th a slight revival took place and during the remainder of the month, spots, mainly in the southern hemisphere, were present.

October: Five groups in all were observed during this month, but only two persisted during the entire transit across the disc, one being a fair-sized typical group near the equator in the first half, and the other a stream of small spots in the south latitude, in the latter half of the month.

November: The early portion of the month and the three closing days were spotless. From the 15th to 26th a large and

interesting group was in north latitude, but owing to cloudy weather only a few observations of it were secured.

December: Only ten observations were obtained this month owing to cloudiness, and upon seven of these dates, no spots were visible. Only small dots were noted on 16th to 18th.

The following table exhibits the numerical results of the observations for the year:

Months 1902.	Number of Observing Days.	Average Number of			Average No. of Groups.		Number of Spotless Days.
		Groups.	Spots.	Faculae.	N. Lat.	S. Lat.	
January	23	0.4	2.0	0.2	0.00	0.40	14
February	19	0.0	0.0	0.0	0.00	0 00	19
March	18	0.7	5.9	0.4	0.61	0.06	9
April	20	0.0	0.0	0.3	0.00	0.00	20
May	20	0.4	0.8	0.4	0.40	0.00	12
June	20	0.1	0.3	0.3	0.15	0.00	17
July	24	0.2	0.3	0.5	0.17	0.00	20
August	24	0.1	0.2	0.2	0.20	0.00	21
September	22	0.5	2.6	0.6	0.27	0.27	14
October	17	1.3	7.6	0.7	0.30	1.00	2
November	13	0.4	3.5	1.1	0.38	0.08	8
December	10	0.3	0.9	1.4	0.30	0.00	7

There were 163 spotless days out of 230 days of observation, compared with 212 in 269 days in 1901 or a decrease of about 8 per cent. Faculae were absent on 142 days. In the subjoined table is given the annual average results for the years 1891 to 1902 for comparison:

Years.	Number of Days of Observations.	Average Annual Number of			Total Number of Spotless Days.	Per Cent of Spotless Days.
		Groups.	Spots.	Faculae.		
1891	257	2.9	14.9	3.6	24	9.3
1892	205	5.6	34.0	4.1	0	0.0
1893	177	6.6	36.6	4.1	0	0.0
1894	139	5.6	30.0	3.4	0	0.0
1895	149	5.2	30.5	3.5	0	0.0
1896	197	3.2	17.8	2.9	5	2.5
1897	198	2.2	11.0	2.3	29	14.6
1898	234	2.1	11.0	2.4	30	12.8
1899	259	1.1	4.8	1.5	108	41.7
1900	255	0.7	3.4	1.0	134	52.5
1901	269	0.25	0.9	0.3	212	78.8
1902	230	0.37	2.0	0.5	163	70.9

ALTA, Iowa, September 1903.

THE SMALL TELESCOPE IN THE HIGH SCHOOL.

W. W. PAYNE.

Since calling attention to the advantages of a three-inch telescope mounted on tripod in alt-azimuth way, as given in the October number of this publication, some queries have come to us asking for further information. It seems to have been something of a surprise that a first rate telescope of that size, and mounted in that way could be procured for less than $100. In being a little more explicit in regard to this size and mounting, it ought to be said that the alt-azimuth mounting for a 3-inch glass is not usual. It is made on special order commonly so far as we know. It is not as expensive as the equatorial mounting, because the two axes for that kind of mounting, and the adaptation of them to the latitude of the place of observation costs considerably more than the simpler arrangement that is called by the name of alt-azimuth. The difference between the two is simply this: the equatorial mounting has for its principal great circle in the sky the celestial equator. Motion of the instrument in this great circle is secured by rotating it about the polar axis. Motion perpendicular to the celestial equator is obtained by means of the declination axis. North-and-south motion of the telescope in the sky is secured by rotating the instrument about the last-named axis. The altitude and azimuth telescope has the horizon for its principal great circle of reference. So motion in azimuth is secured by means of a vertical axis and motion in altitude is obtained by turning the instrument about a horizontal axis. This latter kind of mounting is more simple and just as convenient as the other with the exception of following celestial object in their apparent daily motion. When the telescope is clamped on a star, on account of the rotation of the Earth on its axis to the eastward, the telescope will be carried by the star in the same direction, or, in other words, the star will seem to move out of the field of view of the telescope to the westward. If the telescope is provided with slow-motion screws the observer will need to move the telescope, both in altitude and in azimuth, by the slow-motion apparatus to keep up with the star. If the mounting is equatorial in form, the observer will need to give his telescope motion only in a direction parallel to the celestial equator and the following of the instrument will be satisfactory. This difference in favor of the last named instrument is slight when the purpose of the observer is simply to

view celestial objects to gain knowledge of their appearance in this way and when nothing more is expected.

We have been thus explicit, in stating a few things about the mounting of a small telescope, all of which, and much more like them, are very well known to amateur observers that have used the telescope somewhat, but they are said, in this connection in the hope of aiding those who do not know, as they wish to, about these very elementary matters. They are at the beginning of observational work in elementary astronomy.

In the next place we had planned to give an idea of more work that might be done by the high school teacher, for his own benefit, and for the benefit of his classes in the brief matter that can be presented at this time; but by the last mail an important letter comes to hand, which evidently was brought out by our article in the October number just referred to, in which the writer refers to some very important matters that have been in our own mind for some years past.

The writer of the letter is one of the foremost scholars in mathematics and astronomy of the present time and he holds a prominent position in a leading institution of learning in a great city. He says:

"The spirit which your article on 'The Small Telescope in the High School' breathes persuades me to believe you open to conviction, as to the importance of a series of papers in POPULAR ASTRONOMY, on the teaching of astronomy, as a science in the high school. Most high school astronomy is being dropped because teachers, as a rule, do not seem to see anything in it, but the study of a text-book. For a science this method of study is antiquated, and on account of it, astronomy bids fair to be driven out of the high school almost entirely, unless there shall be a change in the method of teaching it. Astronomy, if presented to classes in the method of other modern sciences is not difficult for high school students to understand, but peculiarly easy and intensely interesting.

"Elementary astronomy should hold a distinct place in high school work, because it trains students in the scientific methods of thinking which they cannot get elsewhere in the effective way."

The writer concludes this private letter by saying, we ought to head a pedagogic movement for the restoration of high school astronomy to the place it ought to hold in a course of study best adapted to needs of the modern high school.

We believe the demand for just this thing is so imperative that

somebody who has the time and the ability to launch such a new scheme for elementary astronomy will do it, and that, too, very soon. The person who undertakes this task should be an experienced teacher in science and in astronomy particularly. He should know practical astronomy. He should know the best methods and he should have ample means of illustrating his methods that will not end in the study of the text-book, but will certainly lead the student into a quenchless desire to know more, to ask questions, to use his eyes and all other means within his reach to gain more knowledge of this great universe that is constantly about him on every side, for his whole natural life upon the Earth. If the student is taught to begin this right way of thinking in his early years how it will grow upon him as life advances! How much larger and grander will the meaning of an earthly life be to say nothing of the infinite possibilities of another life beyond!

If we are to have a new way of teaching elementary astronomy in high schools it will mean the preparation of a manual or guide for teachers and students to enable them to carry out some suitable plan that may be devised in the direction which we have heretofore suggested. Such a text-book should have a system of graded exercises in observation and practice work that the student may rightly exercise his varied powers in a way to make the most of them, so that he shall be conscious of the steady increase in knowledge and power in the pursuit that occupies his mind.

Some teachers in astronomy have felt the need of the change of method herein suggested, and they have made earnest efforts in the past for a reform. Text-books have been written embodying their ideas, and publishers have earnestly tried to forward these new methods, but none of them seem to have succeeded generally so as to get the attention and to win the support of the schools, for which the reform is primarily intended.

It seems to us that this important change in the method of teaching astronomy will not take place, in any large way, until teachers of this branch of science shall come together, discuss the needs, formulate a general plan for the new method, discuss the plan so provided, amend it if desirable, until it shall meet the widest approval possible, so that when it is undertaken, it shall have such a general and such an intelligent support that it will command the attention of school authorities and make its acceptance both easy and natural.

It would seem proper in this connection to notice many of the

individual efforts that have been put forth during the last few years, to meet this demand, but there are so many of them that it would scarcely be fair to begin such a task without being prepared to present a full list with appropriately descriptive notes. That we can not now do, and must be content for the present with the general statements.

We, however, do ardently wish and hope that all lovers of astronomy in the teaching lines will faithfully consider the situation here outlined and be ready in the near future to second and heartily support any right movement that may be inaugurated.

ORIGIN OF THE TIDES.

ARTHUR K. BARTLETT.

FOR POPULAR ASTRONOMY.

In the Sunday Inter-Ocean of Sept. 15, 1901, there appeared, under prominent headlines, a lengthy article entitled "Newton's Theory Held a Fallacy," by Wm. Rosser Cobbe, "Former Professor of Physics at the United States Naval Academy," containing some erroneous statements which should no longer he permitted to remain unchallenged, as they can not fail to have an unfavorable effect and produce a false impression in the minds of persons not specially familiar with the subject.

The author of the above mentioned article is unknown to the writer, who never before even heard of his name though familiar with all the recognized authorities, but in justice to the public his unscientific remarks ought to be corrected and explained. The writer has been waiting long and patiently in hopes that some one more capable would before now reply to the article, but as no criticism has appeared, much to his surprise and regret, he feels it incumbent upon himself, as an earnest student of astronomy, to do what he can, even at this late date, to correct the untruthful statements, and prevent them from being accepted as demonstrated and undisputed facts by thousands of otherwise intelligent readers throughout the country.

In the article to which we have called attention the writer thus refers to the tides:

"Why might it not have occurred to Sir Isaac Newton that the Earth itself is responsible for the tides? Such an explanation might be plausible and might appeal to common sense. Would it not be reasonable to believe that the tides are caused by the revolution of the Earth and that the Moon has nothing to do

with them? The Earth is not precisely round. Its revolutions are not performed with perfect smoothness. It is inconceivable that the waters which cover three-fourths of the entire surface could be placid, while this persistent and somewhat unsteady revolution is going on. Why is it not reasonable to accept a theory, then, that the tides are caused, not by the Moon, but by the Earth itself; that the regular rise and fall are due to the revolution of the Earth, and that this rushing to and fro of the waters of the seas serves as a sort of ballast to the Earth in its daily rounds, as water is used in the holds of ships to balance them? If it be accepted that the phenomenon of the tides is due to the revolution of the Earth upon its axis, it is easy enough to understand how there is synchronism in Moon and tide movements. The one plausible argument for the Moon's control lies in the simple fact that there is isochronism. But the concurrent movement is explained upon the hypothesis that the position of the Moon and the state of the tides are both due to the revolution of the Earth upon its axis."

The above extract contains many glaring errors in regard to the tides which any student of astronomy, especially a "former professor," should have been able to avoid. He fails to explain in what way the Earth's revolution on its axis can cause the tides, and does not account for the tides being about fifty minutes later each day. It is known that the tides are caused by the Sun and Moon, and that the Earth is not responsible for them. Its rotation is performed with "perfect smoothness" and it has no "unsteady revolution," which is always uniform and invariable. The writer's remark about the rushing of the waters serving as a "ballast" is ridiculous, as is also his statement that the position of the Moon and state of the tides are both due to the revolution of the Earth upon its axis." He is evidently ignorant of the subject or a forgetful student.

He even denies in the same article the attraction of gravitation which has long been accepted by astronomers as an established fact, and which alone causes and explains the occurrence of the tides, as known to every student and taught in every text-book on astronomy. He claims Sir Isaac Newton's theory of gravitation is "a fallacy," and that an apple falls to the ground because it is "heavier than air," not knowing, or being oblivious to the fact that it is the mysterious power of gravitation which gives the apple weight, making it "heavier than the air through which it passes," and causing it to fall to the ground. Without gravitation there could be no such thing as weight, the very term

"gravity" implying "weight," and nothing else but gravitation can account satisfactorily for the tides, as the above writer and "former professor" ought to know, if he is familiar with even the rudiments of astronomy.

An excellent text-book on astronomy by Professors Newcomb and Holden contains these remarks on the theory of gravitation: "The real nature of the great discovery of Newton is so frequently misunderstood that a little attention may be given to its elucidation. Gravitation is frequently spoken of as if it were a theory of Newton's and very generally received by astronomers but still liable to be ultimately rejected as a great many other theories have been. Not infrequently people of greater or less intelligence are found making great efforts to prove it erroneous. Every prominent scientific institution in the world frequently receives essays having this object in view. Gravitation is, properly speaking, the force which makes all bodies here at the surface of the Earth tend to fall downward; and if anyone wishes to subvert the theory of gravitation, he must begin by proving that this force does not exist. This no one would think of doing."

An amusing story has been told which affords a good illustration of the ignorance and popular notions regarding the tides prevailing, even among persons of average intelligence. "Tell me," said a man to an eminent living English astronomer not long ago, "is it still considered probable that the tides are caused by the Moon?" The man of science replied that to the best of his belief it was, and then asked in turn whether the inquirer had any serious reason for questioning the relationship. "Well, I don't know," was the answer; "sometimes when there is no Moon there seems to be a tide all the same."

In explaining the tides according to his absurd theory the "former professor" says:

"The Earth performs its revolution once in 24 hours. This gives the Moon approximately twelve hours for facing each hemisphere. So there are two tides each 24 hours. Let it be observed that it is the Earth which revolves in these 24 hours. The Moon completes its circuit of the Earth in about 29 days."

The time of high or low tide and the relative position of the Moon is not a mere "coincidence" and the Moon not only "serves as an excellent clock for the tides," as he suggests in the same paragraph, but the tides depend upon the position of the Moon, which is the direct cause of their occurrence. The Earth rotating once in 24 hours causes the tide to recur regularly, and the Moon being on opposite sides of the Earth, "facing each hemisphere"

as he says, accounts for the two tides each day. He appears to be ignorant of the simple fact that "the Moon completes its circuit of the Earth" in about 27⅓ days, and not in "about 29 days," which is the approximate period between two "new" or "full" moons, the correct time being nearer to 29½ days. The word "revolution" as applied to the Earth turning upon its axis should be rotation, and this improper use of the term, which refers to a planet's orbital motion as commonly employed, occurs frequently throughout the article.

But it really contains errors too numerous to mention, and too absurd to be corrected, so that we will give them no attention here, and dismiss his elaborate and unscientific newspaper production without further consideration, as being not only misleading, but unworthy of the time spent in reading it except for amusement and criticism, for such writings are an imposition upon and an injustice to the public, and should not be permitted to appear in print.

BATTLE CREEK, Mich.

THE VATICAN OBSERVATORY.*

W. ALFRED PARR.

When towards the middle of the ninth century Pope Leo IV sought to stem the further ravages of the Saracen hordes by strengthening the defences of Rome and enclosing the Vatican hill with massive turreted walls, he could little imagine that these same walls, designed so well to bear the engines of war that were to dominate the country round, would, more than a thousand years later, be required by a successor and namesake to harbor a weapon of science of a potency little dreamt of in those days—a weapon whose range of power should penetrate to the confines of the unknown itself. For, after the conclusion of the International Photographic Conference on the charting of the heavens, held in Paris in 1889, it was on one of the strongest of the towers forming part of the ancient Leonine wall that the late Pontiff, Leo XIII, decided to erect the newly-ordered astrographic telescope which was to enable the Vatican Observatory, until that time somewhat meagrely equipped, to worthily enter the lists with the seventeen other observatories to whom the work of the chart had been allotted.

* *Knowledge*, September, 1903.

The history of the Vatican Observatory is no less interesting than varied. Closely associated in its earliest years with one of the most memorable achievements in the annals of mathematical science—the reform of the calendar in 1582, under Gregory XIII,—it was shortly afterwards suffered to lapse into complete neglect for nearly a century and a half. Gregory, however, may be said to have founded the Observatory when he erected that lofty portion of the Vatican Palace known as the "*Torre dei Venti*," not, as some rather uncharitably maintained, in order merely to enjoy the extended view obtainable from its summit, but in order to institute the study of celestial phenomena in general. That the latter purpose was the true one seems amply evidenced by the tower being referred to in the inscriptions as the "*turris astrorum speculatrix*," and by the fact that it contained the meridian line, constructed to demonstrate to Gregory that, in his time, the Sun no longer entered the sign Aries on the orthodox 21st of March; a circumstance which, as seriously affecting the date of Easter, gave Gregory the opportunity of conferring a lasting *éclat* on his pontificate by undertaking the long desired reform of the calendar. This reform, projected by the Neapolitan physician and astronomer, Lilio, and afterwards more fully demonstrated by the Jesuit, Clavius, was established by papal brief in 1582, but so strong was the feeling against the measure in all countries not adhering to the Church of Rome that it was not adopted by Germany until after the energetic representations of Leibnitz, and others in 1700, nor by England until more than half a century later, when its introduction met with the greatest opposition, while Russia disregards it even today. The significant appearance on the official seal of the Vatican Observatory of the Ram's Head, symbolical of the Sun's position at the vernal equinox, still serves to commemorate the connection between the Gregorian Tower and the Gregorian Calendar. Though, from its height of 73m. above sea level, well enough adapted for the astronomical work of those times, the "Tower of the winds" did not long enjoy its reputation as an Observatory, and it was only towards the end of the eighteenth century that it began, in a measure, to regain the importance of its earlier days. Meteorology, however, rather than astronomy, now formed the chief study, for it had been found that, as the vast dome of St. Peter's somewhat impeded the view towards the south, the site was less favorably placed for astronomical work than that occupied by the Observatory of the Collegio Romano, erected in 1787, and rendered famous through the labors of De Vico and his illus-

trious successor Secchi. Nevertheless, for some thirty years after 1789 the Vatican Observatory continued to display considerable activity in observational work under Gilii, but after his death in 1821 it again fell into disuse, the instruments becoming gradually dispersed and the place itself deserted, until, after the political events of 1870, when the Italian troops took formal possession of the Eternal City, and Pius IX entered upon his self-imposed imprisonment in the Vatican, the locale of the Observatory, owing to the exigencies of space, was finally transformed into dwelling apartments.

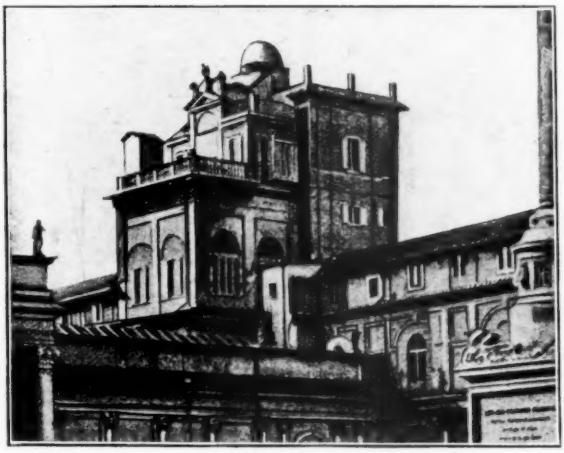


FIG. 1. THE GREGORIAN TOWER OF THE VATICAN OBSERVATORY.

But in spite of this fall, the strangely chequered fortunes of the venerable institution were not to end here, for the Observatory was soon to enter upon the last and most active period of its existence—that which recognizes in it the well-known and well-equipped *Specola Vaticana* of today. The immediate cause of this resuscitation was the scientific exhibition held at Rome in 1888 to commemorate the Jubilee of Leo XIII. At its close the late Father Denza, whose name had been for many years before the scientific world, suggested to the Pope that the collection of instruments forming part of the exhibition should be made use of to reconstitute the Vatican Observatory. The project not only met the immediate approval of Leo XIII, himself a mathematical prizeman of earlier years, but was so enthusiastically carried through that by the summer of 1889 Denza had nearly all his in-

struments installed, and was able to attend the International Photographic Congress at Paris as representative of the Vatican Observatory, and to claim for the newly reconstructed institution a place among the eighteen great observatories taking part in Admiral Mouchez's grandiose scheme of charting the heavens. Under the formal directorship of Denza the Observatory was now equipped with all the most modern meteorological, magnetic and seismological instruments, many of them being the first to be introduced into an Italian Observatory, while its purely astronomical department was enriched by the addition of the astro-

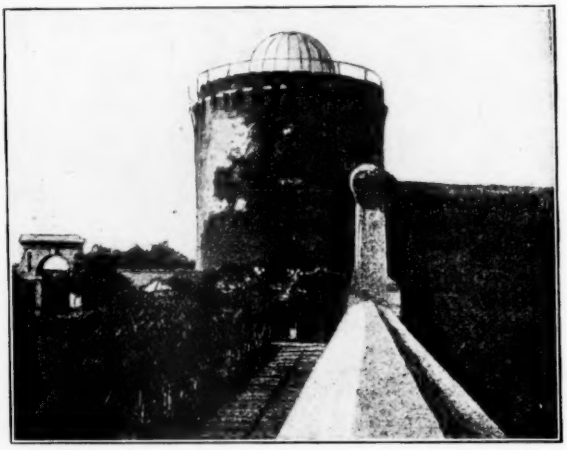


FIG. 2. THE LEONINE TOWER.

graphic telescope constructed in Paris by the Brothers Henry, and mounted by Gautier, of the Paris Observatory. This instrument, which, like its Paris congener, is mounted on the so-called English system, is carried on piers of white Carrara marble, and consists of the usual pair of telescopes contained in a rectangular case of metal, the photographic telescope having the regulation aperture of 33cm. to a focal length of 3.43m., and the visual one an aperture of 20cm, to 3.60m. focal distance. It was placed in position in May 1891, on the strongest of the towers belonging to the ancient Leonine wall mentioned above.

Curious as was the anachronism of fitting one of the most specialized products of the nineteenth century to a structure dating from the ninth, the old Leonine tower nevertheless proved itself admirably adapted for the novel purpose to which it was

put; for situated as it is on the summit of the Vatican hill some 400m. distant from the Gregorian tower with which it is in telephonic communication, and, with its colossal walls of over 4m. thickness, almost a monolith in strength, it unites in the happiest manner the elements of isolation and solidity so essential to the delicate nature of the work carried on beneath its modern dome.

Though primarily designed to co-operate with the great observatories in the work of the International astrographic chart and catalogue, the photographic department of the Vatican Observatory has by no means limited its activities to mere routine work, but has secured several good solar and lunar photographs in addition to its fine studies of nebulæ and star clusters, while a speciality has been made of cloud photography, the Vatican being well represented in this department at the Royal Meteorological Society's Exhibition, held in London in 1890, for the application of photography to meteorology.

Under Denza, who worked assiduously at his post as director until his death in December 1894, the Vatican Observatory rose to renewed life and activity, and conjointly with its sister establishment in Sicily, Catania, entered with enthusiasm upon its share of that great international undertaking which was to bequeath to future times a photographic record of the entire heavens at the close of the nineteenth century. It was, however, reserved for Denza's successor to the directorship, Father Rodriguez, to whose kindness and courtesy I am indebted for many of the above details, as well as for the accompanying photographs, to see this monumental work (which requires some eleven thousand plates in order to cover the whole sky) brought, after several minor interruptions, to its present more or less completed condition.

OPPOSITION OF EROS (433) IN 1905.

EDWARD. C. PICKERING.

Approximate positions for the planet Eros during its opposition in 1903 were published in *Circular* No. 61. Mr. F. E. Seagrave has kindly computed the positions given in Table I, for intervals of forty days during the years 1904 and 1905. The elements used are those published in the *Berlin Jahrbuch* for 1905, page 428. The Julian Day, omitting the three left hand figures 241, the year, omitting the two left hand figures 19, the number of the month, and the day of the month are given in the

first and second columns. The approximate right ascension and declination for 1900, and the logarithms of the distance of the Sun and of the Earth are given in the four remaining columns.

TABLE I.—Computed Positions.

J. D.	Date. 1904. y	m	d	R. A. 1900. h	m	Decl. 1900. °	′	log *r*.	log Δ.
6481	04	1	1	21	8.4	− 12	8	0.2292	0.3784
6521	"	2	10	22	40.5	− 2	41	0.2057	0.3968
6561	"	3	21	0	18.5	+ 8	39	0.1737	0.3923
6601	"	4	30	2	11.8	+ 19	53	0 1346	0.3727
6641	"	6	9	4	31.3	+ 27	10	0.0935	0.3480
6681	"	7	19	7	9.9	+ 25	13	0.0620	0.3288
6721	"	8	28	9	38.4	+ 13	15	0.0554	0.3220
6761	"	10	7	11	48.2	− 3	11	0.0777	0.3267
6801	"	11	16	13	51.0	− 18	4	0.1165	0.3346
6841	"	12	26	15	55.2	− 27	39	0.1574	0.3338
J. D.	Date 1905. y	m	d	R. A. 1900. h	m	Decl. 1900. °	′	log *r*.	log Δ.
6881	05	2	4	17	56.3	− 30	41	0.1928	0.3136
6921	"	3	16	19	41.3	− 28	20	0.2200	0.2551
6961	"	4	25	21	0.7	− 23	7	0.2387	0.1809
7001	"	6	4	21	45.5	− 17	37	0.2489	0.0559
7041	"	7	14	21	32.0	− 14	5	0.2510	0.9158
7081	"	8	23	20	23.8	− 12	32	0.2450	0.8984
7121	"	10	2	20	6.4	− 10	55	0.2307	0.02 6
7161	"	11	11	20	52.2	− 7	43	0.2078	0.138
7201	"	12	21	22	9.5	− 1	33	0.1765	0.2125

From the values given in Table I, an approximate interpolation was made, substantially as described in *Circular* No. 61. Table II gives in the successive columns for each ten days, the Julian Day, the date, the right ascension and declination for 1900, the logarithms of the distances of the Sun and Earth, and the computed magnitude. The magnitude at distance unity is assumed to be 11.39, and no correction is assumed to be 11.39, and no correction is applied for phase or for variation in light.

TABLE II.—Approximate Ephemeris of Eros.

J. D.	Date 1903-04. y	m	d	R.A. 1900. h	m	Decl. 1900. °	log *r*.	log Δ.	Magn.
6440	03	11	21	19	37	− 19.0	0.244	0.329	14.25
6450	"	12	1	19	59	− 17.7	0.241	0.344	14.31
6460	"	12	11	20	21	− 16.1	0.238	0.357	14.37
6470	"	12	21	20	43	− 14.3	0.234	0.368	14.40
6480	"	12	31	21	6	− 12.3	0.230	0.377	14.43
6490	04	1	10	21	29	− 10.2	0.225	0.384	14.43
6500	"	1	20	21	52	− 8.0	0.220	0.390	14.44
6510	"	1	30	22	15	− 5.6	0.214	0.394	14.43
6520	"	2	9	22	38	− 3.0	0.207	0.397	14.41
6530	"	2	19	23	2	− 0.2	0.200	0.398	14.38
6540	"	2	29	23	26	+ 2.8	0.192	0.397	14.33
6550	"	3	10	23	51	+ 5.9	0.184	0.395	14.29
6560	"	3	20	0	16	+ 8.9	0.175	0.392	14.23
6570	"	3	30	0	42	+ 11.9	0.166	0.388	14.16
6580	"	4	9	1	9	+ 14 8	0.156	0.384	14.09
6590	"	4	19	1	38	+ 17.5	0.146	0.379	14.01
6600	"	4	29	2	8	+ 20.1	0.136	0.374	13.94
6610	"	5	9	2	40	+ 22.5	0.125	0.368	13.85
6620	"	5	19	3	14	+ 24.5	0.115	0.362	13.77

TABLE II.—Continued.

J. D.	Date 1903.04. y	m	d	R.A. 1900. h	m	Decl. 1900. °	log r.	log Δ.	Mogn.
6630	"	5	29	3	50	+ 26.0	0.105	0.356	13.69
6640	"	6	8	4	27	+ 27.1	0.095	0.349	13.61
6650	"	6	18	5	5	+ 27.7	0.086	0.343	13.53
6660	"	6	28	5	44	+ 27.6	0.077	0.338	13.47
6670	"	7	8	6	24	+ 26.9	0.069	0.333	13.40
6680	"	7	18	7	5	+ 25.5	0.062	0.329	13.35
6690	"	7	28	7	45	+ 23.3	0.057	0.326	13.31
6700	"	8	7	8	24	+ 20.3	0.054	0.324	13.28
6710	"	8	17	9	1	+ 16.7	0.053	0.322	13.27
6720	"	8	27	9	36	+ 12.9	0.055	0.322	13.27
6730	"	9	6	10	10	+ 9.1	0.059	0.322	13.29
6740	"	9	16	10	42	+ 5.2	0.064	0.324	13.33
6750	"	9	26	11	14	+ 1.2	0.070	0.325	13.37
6760	"	10	6	11	45	− 2.8	0.077	0.327	13.41
6770	"	10	16	12	16	− 6.7	0.085	0.329	13.46
6780	"	10	26	12	47	− 10.6	0.094	0.331	13.51
6790	"	11	5	13	18	− 14.3	0.104	0.334	13.58
6800	"	11	15	13	48	− 17.8	0.115	0.335	13.64
6810	"	11	25	14	19	− 20.9	0.125	0.336	13.69
6820	"	12	5	14	50	− 23.5	0.136	0.336	13.75

J. D.	Date 1904-05. y	m	d	R.A. 1900. h	m	Decl. 1900. °	log r.	log Δ.	Magn.
6830	04	12	15	15	21	− 25.7	0.146	0.335	13.79
6840	"	12	25	15	52	− 27.4	0.156	0.334	13.84
6850	05	1	4	16	22	− 28.7	0.166	0.330	13.87
6860	"	1	14	16	51	− 29.7	0.175	0.326	13.89
6870	"	1	24	17	20	− 30.4	0.184	0.321	13.91
6880	"	2	3	17	49	− 30.7	0.192	0.315	13.93
6890	"	2	13	18	18	− 30.6	0.200	0.307	13.93
6900	"	2	23	18	46	− 30.1	0.207	0.296	13.91
6910	"	3	5	19	13	− 29.3	0.213	0.283	13.87
6920	"	3	15	19	39	− 28.4	0.219	0.267	13.82
6930	"	3	25	20	3	− 27.3	0.225	0.249	13.76
6940	"	4	4	20	24	− 26.0	0.230	0.229	13.69
6950	"	4	14	20	43	− 24.6	0.235	0.207	13.60
6960	"	4	24	21	0	− 23.2	0.239	0.183	13.50
6970	"	5	4	21	15	− 21.8	0.243	0.156	13.39
6980	"	5	14	21	28	− 20.4	0.246	0.126	13.25
6990	"	5	24	21	38	− 19.0	0.248	0.093	13.09
7000	"	6	3	21	45	− 17.7	0.249	0.059	12.93
7010	"	6	13	21	48	− 16.6	0.250	0.022	12.75
7020	"	6	23	21	47	− 15.7	0.251	9.984	12.57
7030	"	7	3	21	42	− 14.9	0.251	9.948	12.39
7040	"	7	13	21	33	− 14.2	0.251	9.918	12.23
7050	"	7	23	21	19	− 13.7	0,250	9.897	12.13
7060	"	8	2	21	1	− 13.3	0.249	9.887	12.07
7070	"	8	12	20	42	− 12.9	0.247	9:887	12.06
7080	"	8	22	20	25	− 12.5	0.245	9.898	12.11
7090	"	9	1	20	12	− 12.1	0.242	9.919	12.19
7100	"	9	11	20	4	− 11.8	0.239	9.948	12.33
7110	"	9	21	20	2	− 11.4	0.235	9.983	12.48
7120	"	10	1	20	6	− 11.0	0.231	0.019	12.64
7130	"	10	11	20	13	− 10.5	0.227	0.053	12.79
7140	"	10	21	20	23	− 9.7	0.222	0.084	12.92
7150	"	10	31	20	35	− 8.8	0.216	0.112	13.03
7160	"	11	10	20	49	− 7.8	0.209	0.136	13.11
7170	"	11	20	21	6	− 6.6	0.202	0.158	13.19
7180	"	11	30	21	25	− 5.2	0.195	0.178	13.25
7190	"	12	10	21	45	− 3.6	0.187	0.196	13.31
7200	"	12	20	22	7	− 1.7	0.178	0.211	13.33

It will be noticed that this is one of the most unfavorable oppositions that can occur. Eros is in aphelion on July 5, 1905, and in opposition on August 7, 1905. At no time during 1904 and 1905 is it brighter than the twelfth magnitude. The most important observations that can be made during this opposition are those of the variation in light, both visually and photographically. Excellent light curves of Eros have, however, been obtained this year by Professor Bailey at Arequipa, with the 13-inch Boyden Telescope, although the planet was fainter than the twelfth magnitude. It seems probable therefore that valuable observations may be obtained in 1905, with the numerous large reflectors and refractors available. The planet's position in the sky will be, in general, nearly opposite to that it had in the spring of 1901, when its variability was discovered.

HARVARD COLLEGE OBSERVATORY,
Circular No. 73.

PLANET NOTES FOR DECEMBER.

H. C. WILSON.

Mercury having been at superior conjunction on Nov. 21 will be invisible during the first half of December but may be seen as evening star toward the southwest during the last week of the year. One must look for this planet about a half hour after sunset and it is not usually visible for much more than a half hour. The twilight is too strong during the first half hour and the planet sets within a little more than an hour after sunset. On Dec. 8 Mercury and Uranus will be in conjunction, but both will be invisible at that time.

Venus is the bright morning star seen toward the east and is now at greatest elongation from the Sun. The phase of the planet is just half full and will increase slowly during the month, as Venus passes toward the farther side of her orbit.

Mars is still to be seen toward the southwest very early in the evening, but at too low an altitude for observations of any value. Mars and Saturn will be in conjunction at 6 P. M. on the evening of Dec. 20, and it may be possible then to see both planets at the same time with a telescope of low power. Mars will be about half a degree south of Saturn.

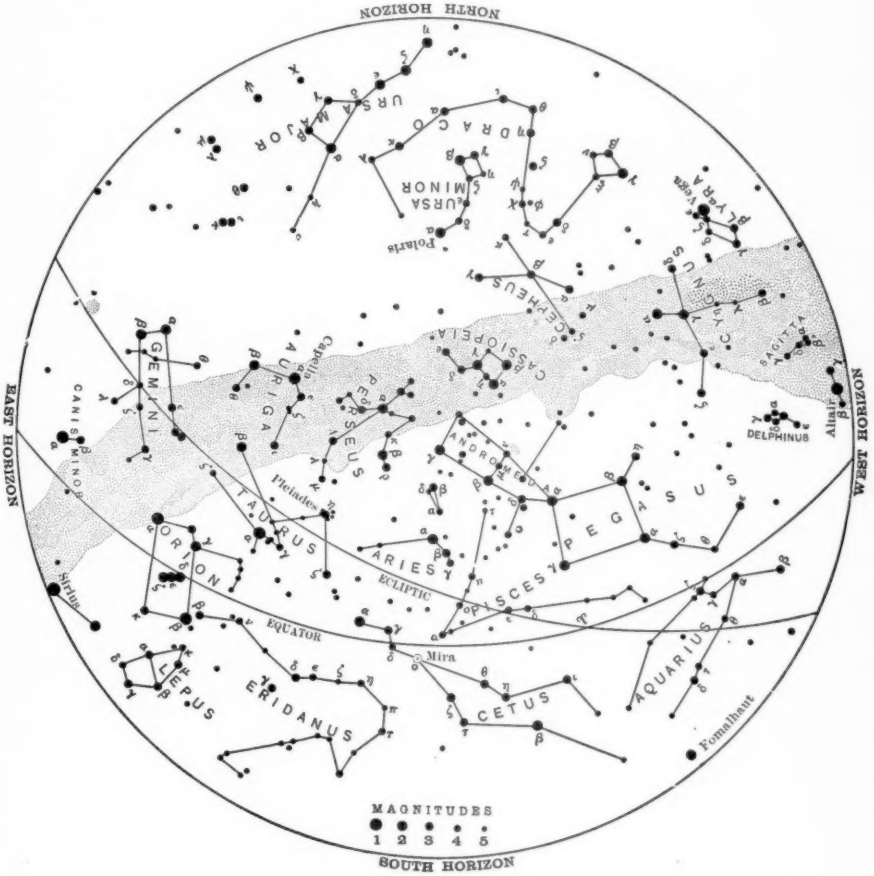
Jupiter is a splendid object now in the evening, being near the meridian at seven o'clock. The belts of Jupiter are easily seen and, with a powerful telescope and good seeing, exhibit a wonderful wealth of detail. Jupiter will be at quadrature 90° east from the Sun on Dec. 7.

Saturn is now too low in the west in the early evening for satisfactory observation.

Uranus is invisible in the glare of the Sun.

Neptune will be at opposition Dec. 26 and so is now in very good position for observers who wish to follow its movements. It can be seen only with the aid of a telescope and its motion is so slow that even then it is difficult to recognize

the planet, unless one has a chart of the stars in the vicinity. With a large telescope the planet may be recognized at once by its disc. No markings have yet been detected with certainty upon the planet. The position of Neptune Dec. 1 is: R. A. $6^h\ 22^m\ 42^s$; Decl. $+\ 22°\ 16'$, or about 35′ east and 18′ south of the third magnitude star μ Geminorum.



THE CONSTELLATIONS AT 9 P. M. DECEMBER 1, 1903.

The Moon.

	Phases.		Rises. (Central Standard Time at Northfield Local Time 13m less.)		Sets.	
			h	m	h	m
Dec.	4-5	Full Moon	5	02 P. M.	8	09 A. M.
	10-11	Last Quarter	11	44 "	12	34 P. M.
	18	New Moon	7	11 A. M.	4	54 "
	26-27	First Quarter	11	56 "	12	26 A. M.

Occultations Visible at Washington.

Date. 1903.	Star's Name.	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N pt. °	EMERSION. Washington M. T. h m	EMERSION. Angle from N pt. °	Duration. h m
Dec. 2	W. B. ii, 1033	5.9	5 09	90	6 08	232	0 59
3	55 Tauri	7.3	14 18	112	15 21	239	1 03
3	63 Tauri	5.6	16 03	67	17 00	288	0 57
4	115 Tauri	5.4	17 36	58	18 22	309	0 46
7	29 Cancri	5.9	16 07	90	17 20	307	1 13
23	B.A.C. 7620	6.5	3 29	65	5 01	245	1 32
27	*e* Piscium	5.7	10 28	43	11 30	279	1 02
31	B.A.C. 1526	5.8	16 33	124	17 16	237	0 43

COMET AND ASTEROID NOTES.

Ephemeris of Brooks Comet for the Return 1903-04.

[Computed by P. Neugebauer, A. N. 3868. Continued from p. 349.]

Berlin Midn. 1903.	R. A. h m s	Decl. ° ′ ″	log *r*	log Δ
Dec. 1	22 10 43.51	−13 26 11.8	0.2921	0.26714
2	12 30.37	13 12 41.7		
3	14 17.77	12 59 7.1		
4	16 5.69	12 45 28.2		
5	17 54.13	12 31 45.0	0.2920	0.27616
6	19 43.07	12 17 57.6		
7	21 32.48	12 4 6.0		
8	23 22.36	11 50 10.2		
9	25 12.70	11 36 10.4	0.2921	0.28506
10	27 3.50	11 22 6.5		
11	28 54.74	11 7 58.6		
12	30 46.41	10 53 46.9		
13	32 38.51	10 39 31.4	0.2922	0.29385
14	34 31.03	10 25 12.1		
15	36 23.96	10 10 49.1		
16	38 17.28	9 56 22.5		
17	40 10.97	9 41 52.5	0.2925	0.30253
18	42 5.01	9 27 19.0		
19	43 59.40	9 12 42.2		
20	45 54.13	8 58 2.2		
21	47 49.20	8 43 19.0	0.2929	0.31107
22	49 44.61	8 28 32.8		
23	51 40.34	8 13 43.6		
24	53 36.38	7 58 51.5		
25	55 32.70	7 43 56.6	0.2935	0.31948
26	57 29.30	7 28 59.0		
27	22 59 26.18	7 13 58.8		
28	23 1 23.33	6 58 56.1		
29	3 20.73	6 43 51.0	0.2941	0.32776
30	5 18.37	6 28 43.7		
31	23 7 16.24	− 6 13 34.2		

New Asteroids.—The following have been added to the list of new planets since our last note:

	Discovered By	At	Local M. T. h m	R. A. h m	Decl. ° ′	Mag.
1903 MC	Wolf	Heidelberg Sept. 20	12 29.7	23 21.8	− 6 56	13.0
MD	Wolf	" 20	12 29.7	23 22.7	− 5 15	13.5
ME	Wolf	" 20	12 29.7	23 23.5	− 6 32	13.0
MF	Wolf	" 20	12 29.7	23 24.7	− 4 16	13.5
MG	Dugan	" 20	11 36.6	0 36.8	+16 54	12.0

VARIABLE STARS.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours, etc.]

U Cephei.

	d	h
Dec.	2	5
	4	17
	7	5
	9	17
	12	5
	14	17
	17	4
	19	16
	22	4
	24	16
	27	4
	29	16

Z Persei

Dec.	1	8
	4	10
	7	11
	10	12
	13	14
	16	15
	19	16
	22	18
	25	19
	28	21
	31	22

Algol.

Dec.	3	19
	6	16
	9	12
	12	9
	15	6
	18	3
	21	0
	23	20
	26	17
	29	14

λ Tauri.

Dec.	2	11
	6	10
	10	9
	14	8
	18	6
	22	5
	26	4
	30	3

R Canis Maj.

Dec.	1	6
	2	9
	3	12
	4	15
	5	19
	6	22
	8	1
	9	4
	10	8
	11	11
	12	14

R Canis Maj.

	d	h
Nov.	13	17
	14	21
	16	0
	17	3
	18	7
	19	10
	20	13
	21	16
	22	20
	23	23
	25	2
	26	5
	27	9
	28	12
	29	15
	30	18
	31	22

RR (R^2) Puppis

Dec.	7	7
	13	17
	20	3
	26	14

V Puppis.

Dec.	1	0
	2	11
	3	22
	5	9
	6	20
	8	7
	9	18
	11	5
	12	15
	14	2
	15	13
	17	0
	18	11
	19	22
	21	9
	22	20
	24	7
	25	18
	27	5
	28	15
	30	2
	31	13

S Cancri

Dec.	2	12
	12	0
	21	12
	30	23

S Antliæ.

Period $7^h\ 46^m.8$

Dec.	1	22
	2	22
	3	21

S Antliae

Period $7^h\ 46^m.8$

	d	h
Dec.	4	20
	5	20
	6	19
	7	18
	8	18
	9	17
	10	16
	11	16
	12	15
	13	14
	14	14
	15	13
	16	12
	17	12
	18	11
	19	10
	20	10
	21	9
	22	8
	23	8
	24	7
	25	6
	26	6
	27	5
	28	4
	29	4
	30	3
	31	2

S Velorum.

Dec.	2	16
	8	14
	14	12
	20	11
	26	9

δ Librae.

Dec.	2	7
	3	15
	5	23
	8	7
	10	15
	12	23
	15	8
	17	14
	19	22
	22	6
	24	14
	26	22
	29	6
	31	14

U Coronæ.

Dec.	2	10
	5	21
	9	8
	12	19
	16	5

U Coronae.

	d	h
Dec.	19	16
	23	3
	26	14
	30	1

R Aræ.

Dec.	1	17
	6	3
	10	13
	14	23
	19	10
	23	20
	28	6

Z Herculis.

Dec.	1	17
	3	18
	5	17
	7	18
	9	17
	11	18
	13	17
	15	18
	17	17
	19	18
	21	16
	23	17
	25	16
	27	17
	29	16
	31	17

RX (X^2) Herculis.

Dec.	1	12
	2	10
	3	7
	4	4
	5	2
	5	23
	6	20
	7	18
	8	15
	9	12
	10	10
	11	7
	12	4
	13	2
	13	23
	14	20
	15	18
	16	15
	17	13
	18	10
	19	7
	20	5
	21	2
	21	23
	22	21

U Sagittae.

	d	h
	23	18
	24	15
	25	13
	26	10
	27	7
	28	5
	29	2
	29	23
	30	21
	31	18

RV (V^2)Lyræ.

Dec.	1	11
	5	1
	8	15
	12	6
	15	20
	19	10
	23	1
	26	15
	30	6

U Sagittæ.

Dec.	2	10
	5	19
	9	5
	12	14
	15	23
	19	8
	22	17
	26	2
	29	11

SY (X^3) Cygni.

Dec.	3	23
	9	23
	15	23
	21	23
	27	23

SW (V^3) Cygni.

Dec.	3	2
	7	16
	12	5
	16	19
	21	9
	25	23
	30	12

UW (Z^4) Cygni.

	1	7
	4	18
	8	5
	11	16
	15	2
	18	13
	22	0
	25	11
	28	22

Minima of Variable Stars of the Algol Type.—Continued.

W Delphini			Y Cygni			Y Cygni			Y Cygni			Y Cygni		
	d	h		d	h		d	h		d	h		d	h
Dec.	4	17	Dec.	1	11	Dec.	10	11	Dec.	17	19	Dec.	25	10
	9	12		2	19		11	19		19	11		26	19
	14	8		4	11		13	11		20	19		28	10
	19	3		5	19		14	19		22	10		29	18
	23	22		7	11		16	11		23	19		31	11
	28	17		8	19									

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
		h			h		h		h
V Velorum	Dec. 1	11	Dec. 2	10	R Crucis	Dec. 16	6	Dec. 17	15
T Velorum	1	18	3	3	W Virginis	16	15	24	20
S Trianguli Austr.	1	20	3	22	S Crucis	16	18	18	6
V Carinae	2	4	4	8	δ Cephei	16	19	18	10
S Crucis	2	16	4	11	T Vulpeculae	17	7	18	16
SU Cygni	2	18	4	2	S Sagittae	17	18	21	4
T Vulpeculae	4	0	5	9	SU Cygni	18	3	19	11
V Centauri	4	0	5	11	T Crucis	18	11	20	12
κ Pavonis	4	1	7	20	V Velorum	18	23	19	22
R Crucis	4	14	5	23	RV Scorpii	18	23	20	9
T Crucis	5	0	7	1	β Lyrae	19	19	23	2
W Geminorum	5	3	7	18	η Aquilae	19	21	22	3
ζ Geminorum	5	6	10	6	S Normae	19	22	24	8
η Aquilae	5	12	7	18	T Velorum	20	8	21	17
V Velorum	5	20	6	19	V Centauri	20	11	21	22
δ Cephei	6	1	7	16	W Geminorum	20	15	23	6
T Velorum	6	9	7	18	S Triang. Austr.	20	19	22	21
S Muscae	6	11	9	22	T Vulpeculae	21	18	23	3
SU Cygni	6	14	7	22	S Crucis	21	11	22	23
RV Scorpii	6	20	8	6	SU Cygni	21	23	23	7
β Lyrae	6	21	10	4	R Crucis	22	2	23	11
S Crucis	7	8	8	20	δ Cephei	22	4	23	19
U Vulpeculae	8	0	10	3	V Carinae	22	6	24	10
S Trianguli Austr.	8	4	10	6	κ Pavonis	22	6	26	1
T Vulpeculae	8	10	9	19	V Velorum	23	8	24	7
V Carinae	8	21	11	1	U Vulpeculae	23	23	26	2
S Sagittae	9	8	12	18	T Velorum	24	23	26	8
V Centauri	9	11	10	22	RV Scorpii	25	0	26	10
S Normae	10	4	14	14	T Crucis	25	4	27	5
V Velorum	10	5	11	4	ζ Geminorum	25	13	30	13
SU Cygni	10	10	11	18	SU Cygni	25	19	27	3
R Crucis	10	10	11	19	S Muscae	25	19	29	6
T Velorum	11	1	12	10	V Centauri	25	23	27	10
X Cygni	11	6	18	1	S Crucis	26	3	27	15
T Monocerotis	11	7	19	5	T Vulpeculæ	26	4	27	13
δ Cephei	11	10	13	1	β Lyrae	26	6	29	8
T Crucis	11	17	13	18	S Triang. Austr.	27	3	29	5
S Crucis	12	1	13	13	δ Cephei	27	12	29	3
η Aquilae	12	16	14	22	X Cygni	27	15	34	10
W Geminorum	12	21	15	12	V Velorum	27	16	28	15
T Vulpeculae	12	21	14	6	R Crucis	27	21	29	6
RV Scorpii	12	21	14	7	W Geminorum	28	8	30	23
κ Pavonis	13	4	16	23	V Carinae	28	23	31	3
β Lyrae	13	8	16	10	T Velorum	29	14	30	23
SU Cygni	14	7	15	15	S Normae	29	16	35	2
V Velorum	14	9	15	8	SU Cygni	29	16	31	0
S Triang. Austr.	14	12	16	14	TX Cygni	30	3	35	6
V Centauri	14	23	16	10	T Vulpeculae	30	14	31	23
ζ Geminorum	15	9	20	9	RV Scorpii	31	2	32	12
TX Cygni	15	9	20	12	κ Pavonis	31	8	35	3
V Carinae	15	14	17	18	V Centauri	31	11	32	22
T Velorum	15	16	17	1	T Crucis	31	22	33	23
U Vulpeculae	16	0	18	3	U Vulpeculae	31	23	34	2
S Muscae	16	3	19	14					

Maxima and Minima of Long Period Variables.

[Computed from Chandler's "Third Catalogue." A question mark indicates that the elements are in doubt. By Misses Ida I. Watson and Helen M. Swartz of Vassar College Observatory.]

Maxima.

Date Nov.	No.	Star.
1	5494	S Librae
4	5438?	Y Librae
6	906	R Trianguli
6	5758	X Herculis
7	6044	S Herculis
7	6903	T Sagittarii
9	6132	R Ophiuchi
11	8324	V Cassiopeae
12	782	R Arietis
15	8597	V Ceti
16	7261?	R Delphini
21	6871?	V Lyrae
25	419?	U Andromedae
26	3567	V Leonis

Maxima.

Date. Nov.	No.	Star.
26	6921	S Sagittarii
26	7754	W Cygni
26	7999	X Aquarii
27	7560	R Vulpeculae

Minima.

4	4492	Y Virginis
5	2625	V Geminorum
8	6943?	T Sagittae
9	7220	S Cygni
11	7448	W Aquarii
16	4521	R Virginis
18	7468	T Aquarii
28	8068	S Lacerti

Maxima of U Pegasi.

Period $4^h\ 29^m.8$. The minimum occurs $2^h\ 15^m$ after the maximum.

	d	h	d	h	d	h	d	h
Dec.	1	3	Dec. 9	0	Dec. 17	2	Dec. 25	3
	2	2	10	3	18	0	26	2
	3	0	11	2	19	3	27	0
	4	3	12	0	20	2	28	3
	5	2	13	3	21	0	29	1
	6	0	14	2	22	3	30	0
	7	3	15	0	23	2	31	3
	8	2	16	3	24	0		

Maxima of UY Cygni.

Period $13^h\ 27^m\ 21^s$. The minimum occurs $1^h\ 53^m$ before the maximum.

	d	h	d	h	d	h	d	h
Dec.	1	8	Dec. 9	4	Dec. 17	1	Dec. 24	21
	2	11	10	7	18	4	26	0
	3	14	11	10	19	7	27	3
	4	17	12	13	20	10	28	6
	5	20	13	16	21	13	29	9
	6	22	14	19	22	15	30	12
	7	1	15	22	23	18	31	15

Maxima of Y Lyræ.

Period $12^h\ 3.9^m$.

	d	h	d	h	d	h	d	h
Dec.	1	10	Dec. 9	12	Dec. 17	13	Dec. 25	14
	2	11	10	12	18	13	26	14
	3	11	11	12	19	13	27	14
	4	11	12	12	20	13	28	14
	5	11	13	12	21	13	29	14
	6	11	14	12	22	13	30	14
	7	11	15	12	23	13	31	14
	8	11	16	12	24	13		

Approximate Magnitudes of Variable Stars Oct. 10, 1903.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900.	°		Magn.	Name.	R. A. 1900. h	m	Decl. 1900.	°		Magn. h
T Androm.	0	17.2	+	26	26	13*d*	R Camel.	14	25.1	+	84	17	9*i*
T Cassiop.	0	17.8	+	55	14	8*i*	R Bootis	14	32.8	+	27	10	7*d*
R Androm.	0	18.8	+	38	1	15*f*	S Librae	15	15.6	—	20	2	*s*
S Ceti	0	19.0	—	9	53	8*i*	S Serpentis	15	17.0	+	14	40	10*d*
W Cassiop.	0	49.0	+	58	1	*u*	S Coronae	15	17.3	+	31	44	12*d*
S "	1	12.3	+	72	5	10*d*	S Urs. Min.	15	33.4	+	78	58	9*i*
R Piscium	1	25.5	+	2	22	10*d*	R Coronae	15	44.4	+	28	28	6*i*
R Trianguli	1	31.0	+	33	50	7*i*	V "	15	45.9	+	39	52	*u*
U Persei	1	52.9	+	54	20	8*i*	R Serpentis	15	46.1	+	15	26	10*d*
R Arietis	2	10.4	+	24	36	13*d*	R Herculis	16	1.7	+	18	38	12*i*
o Ceti	2	14.3	—	3	26	9*d*	R Scorpii	16	11.7	—	22	42	13*d*
S Persei	2	15.7	+	58	8	9*d*	S "	16	11.7	—	22	39	10*i*
R Ceti	2	20.9	—	0	38	9	U Herculis	16	21.4	+	19	7	12*d*
U "	2	28.9	—	13	35	9*d*	R Ursae Min.	16	31.3	+	72	28	*u*
R Persei	3	23.7	+	35	20	*u*	W Herculis	16	31.7	+	37	32	13
R Tauri	4	22.8	+	9	56	13*d*	R Draconis	16	32.4	+	66	58	12*d*
S "	4	23.7	+	9	44	15*f*	S Herculis	16	47.4	+	15	7	8*i*
R Aurigæ	5	9.2	+	53	28	11*i*	R Ophiuchi	17	2.0	—	15	58	9*i*
U Orionis	5	49.9	+	20	10	11*d*	T Herculis	18	5.3	+	31	0	11*i*
R Lyncis	6	53.0	+	55	28	7	R Scuti	18	42.2	—	5	49	5*i*
R Gemin.	7	1.3	+	22	52	8*d*	R Aquilae	19	1.6	+	8	5	10*d*
S Canis Min.	7	27.3	+	8	32	11	R Sagittarii	19	10.8	—	19	29	13*d*
R Cancri	8	11.0	+	12	2	7	S "	19	13.6	—	19	12	15*f*
V "	8	16.0	+	17	36	*f*	R Cygni	19	34.1	+	49	58	8*i*
S Hydrae	8	48.4	+	3	27	*f*	RT "	19	40.8	+	48	32	*u*
T "	8	50.8	—	8	46	*f*	X "	19	46.7	+	32	40	6*i*
R Leo. Min.	9	39.6	+	34	58	8*i*	S Cygni	20	3.4	+	57	42	12*d*
R Leonis	9	42.2	+	11	54	6*i*	RS "	20	9.8	+	38	28	8
R Urs. Maj.	10	37.6	+	69	18	7	R Delphini	20	10.1	+	8	47	9*i*
R Comae	11	59.1	+	19	20	*f*	U Cygni	20	16.5	+	47	35	10*i*
T Virginis	12	9.5	—	5	29	*s*	V "	20	38.1	+	47	47	14*f*
R Corvi	12	14.4	—	18	42	*s*	T Aquarii	20	44.7	—	5	31	12*d*
Y Virginis	12	28.7	—	3	52	*s*	R Vulpec.	20	59.9	+	23	26	*f*
T Urs. Maj.	12	31.8	+	60	2	8*i*	T Cephei	21	8.2	+	68	5	10*d*
R Virginis	12	33.4	+	7	32	*s*	S "	21	36.5	+	78	10	10
S Urs. Maj.	12	39.6	+	61	38	8*i*	S Lacertae	22	24.6	+	39	48	8
U Virginis	12	46.0	+	6	6	*s*	R "	22	38.8	+	41	51	9
V "	13	22.6	—	2	39	*s*	S Aquarii	22	51.8	—	20	53	11*d*
R Hydrae	13	24.2	—	22	46	*s*	R Pegasi	23	1.6	+	10	0	10*d*
S Virginis	13	27.8	—	6	41	*s*	S "	23	15.5	+	8	22	12*i*
R Can. Ven.	13	44.6	+	40	2	10*d*	R Aquarii	23	38.6	—	15	50	10*i*
S Bootis	14	19.5	+	54	16	9*i*	R Cassiop.	23	53.3	+	50	50	10*i*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that its light is increasing; *d*, that its light is decreasing; *s*, that it is near the Sun; *u*, that its magnitude is unknown.

Derived from observations made at the Halstead, McCormick, Eadie and Harvard Observatories, Oct. 10, 1903.

New Variable ...1903, Cygni.—This was announced by cable from Kiel Observatory Oct. 5 as a new star discovered by Professor Wolf at Heidelberg, Germany, Sept. 21.4388 Gr. M. T. in right ascension $20^h\ 14^m\ 57^s.0$ and declination $+37°\ 09'\ 49''$. The position is referred to the equinox of 1903.0. Later telegrams announce that the star is not new but is a variable, and that it is identical with the star BD $+37°.3876$. In the BD it is given as 9.5 magnitude. On a photograph taken at Goodsell Observatory on the night of Oct. 9

with the 8-inch refractor, exposure 30 minutes, no star is found in the place of the variable; but on Oct. 12 a faint star of about the 11th magnitude and of a dull ruddy color was observed visually with the 16-inch refractor.

In the *Astronomical Bulletin* No. 145 of the Harvard College Observatory, Professor Pickering states that the star is found on a large number of photographs taken at Cambridge from Oct. 29, 1891 to the present time, and that it varies more than two magnitudes. A plate taken July 30, 1895 shows that its spectrum was then of the fourth type. In *Bulletin* No. 144 Professor Pickering states that *P* Cygni, Janson's new star of 1600, precedes this object by $0^m\ 44^s$, north 34'.0.

New Variables 56 and 57.1903.—These are announced by Professor Ceraski in *A. N.* 3903 and were found by Mme. L. Ceraski upon the photographs taken at Moscow Observatory. Their positions are:

	R. A. 1855. h m s	Decl. 1855. ° ′ ″	R. A. 1900. h m s	Decl. 1900. ° ′ ″
56.1903 Cephei	2 24 14.5	+ 80 30 13	2 29 23.3	+ 80 42 19
57.1903 Ursæ Min.	13 31 42.3	+ 74 10 12	13 32 37.9	+ 73 56 22

Both vary from about the 9th magnitude to below the 13th magnitude, the former in a period of about 390 days, the latter in about 323 days.

SS Cygni.—In *A. J.* 547 Mr. Zaccheus Daniel gives a large number of observations of this variable, concerning which he makes the following remarks: "*SS* Cygni has recently acted in a very strange manner. The maximum in February was anomalous in form, and similar to that of December, 1899, a curve of which was published by J. A. Parkhurst in POPULAR ASTRONOMY, Vol. 8, p. 46, and the *Astrophysical Journal*, Vol. 12, p. 268. The observations indicate a standstill at a point where the rise is usually very rapid. The maximum was also observed by Hartwig (*A. N.* 3866). After a short period of normal brightness following the April maximum, I found it on May 10, apparently, somewhat brighter, but in a few days it returned to normal. On May 25, however, it was certainly above normal, but a few days later it had become faint again. That was probably the end of a short maximum. The next maximum was also short. The rise began on June 21. On the decrease, a standstill occurred at $10^m.5$. The maximum in July is noteworthy in that the decrease was somewhat checked toward the end, the approach to normal brightness being comparatively slow. This has also been observed at several previous maxima."

GENERAL NOTES.

Bulletins 3 and 4 of Lowell Observatory have been received. The first gives a spectroscopic investigation of the rotation velocity of Venus. The second treats of the efficiency of the spectrograph for investigating planetary rotations, and of the accuracy of the inclination method of measurements. With this are given tests on the rotation of the planet Mars. The work is done by V. M. Slipher.

The Astronomische Rundschau No. 48, Band V. has a series of fine drawings of the surface markings of the planet Jupiter for June and July in the year 1899, and in July 1900, and July and August 1901. These drawings show a large number of light and dark spots in the neighborhood of the great belts,

and some of the fainter ones beyond. If these drawiugs are correct the spots, both black and white, show great contrast with the color of the belts when they are found.

"Cycles of Eclipses" is continued in *Knowledge* for October by A. C. D. Crommelin in the third part of this interesting paper. The first accompanying illustration gives eight paths of totality, in pairs for general direction of march as follows: 1600 July, 1900 May 28; 1601 June 30, 1901 May 18; 1596 Sept. 22, 1896 Aug. 9; 1598 May 7, 1898 Jan. 24. The other charts help the text.

Nova Persei.—Also from *Bulletin* No. 48 Mr. Perrine says that, in recent observations the line at λ 339 has disappeared entirely, and that at λ 346 is distinguishable only a very slight brightening in the continuous spectrum, the latter extending to λ 334. The nebular line at λ 501 seems to be but little changed in brightness.

On July 30 this variable was estimated to be 11½ or 12 magnitude.

Nova Aurigæ.—In the Lick Observatory *Bulletin* No. 48, C. D. Perrine says the recent observations of this variable star fail to disclose any trace of the nebular line at λ 501.

The magnitude of the Nova is now about 14. The 13½ magnitude star at a distance of 2′ from it, in position-angle 40, gives a spectrum resembling *R* Leonis and similar variables when near maximum. No variations of brightness are shown, however, on the few plates of this region which have been secured.

Nova Geminorum.—Under date of Sept. 9, 1903, Mr. Perrine, in Lick Observatory *Bulletin* No. 48 says:

"The line at λ 346, which was discovered by Mr. Palmer to exist in some of the nebulæ, appeared in Nova Geminorum at about the same time as, or a little later than, the nebular line at λ 501.

"The line at λ 346 and its companion at λ 339, although among the strongest in the spectrum of Nova Persei, were the first to disappear.

"In Nova Aurigæ, which has reached a later stage than either Nova Geminorum or Nova Persei, we have observed the extinction of the nebular line at λ501, since 1901, and a closer approach to the ordinary type of stellar spectrum.

"It can scarcely be doubted that the spectra of the three recent novæ are destined to attain the same character as those of the great majority of the stars and as that which Palmer has shown Nova Cygni to have reached,—*i. e.*, a continuous spectrum without bright lines;—and that the whole cycle of changes will occupy but a few years, even in the case of so great an outburst as that of Nova Persei."

Meteors Observed at Leander McCormick Observatory.—During the past summer meteors were observed here on the nights of July 20, 21, 23, 24, 27 and 28, and on Aug. 11 by me, and on July 28 and Aug. 11 also by Mr. G. F. Paddock of this Observatory. The number of meteors observed by Mr. Paddock was 51, by me 244, seven being duplicates, making the total 288. On Aug. 11 the rate of the Perseids was one every 7.4 minutes according to my observations between $11^h.3$ and $15^h.6$. The rate was increasing during the latter

part of the watch in spite of cloud and smoke which was then rising. The following radiant points were deduced, the positions being given to the nearest degree:

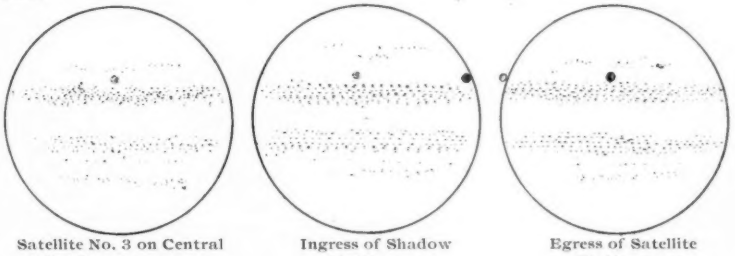
Date 1903.	α	δ	No.s	Observed.	Spots.
July 20.5	274	+ 40	4	O	
21.5	24	+ 50	8	O	Perseids.
23.6	26	+ 52	6	O	Perseids.
24.6	3	+ 30	5	O	
27.6	338	— 17	4	O	δ Aquarids.
27.6	351	+ 49	4	O	
27.6	300	+ 50	6	O	
27.6	342	+ 62	9	O	
28.6	33	+ 55	3	O	Perseids.
28.6	338	— 14	12	O	δ Aquarids.
28.6	353	+ 22	6	P	
28.6	36	+ 56	4	P	
28.6	296	+ 8	5	P	
28.6	22	+ 59	3	P	
Aug. 11.5	44	+ 45	3	P	
11.5	27	+ 55	5	P	
11.5	23	+ 52	3	P	
11.6	44	+ 56	16	O	Perseids.

CHARLES P. OLIVIER.

LEANDER MCCORMICK OBSERVATORY,
University of Virginia.

Dark Transit of Jupiter's Third Satellite.—September 28th at 6:00 P. M. I set my 5-inch telescope on Jupiter for the purpose of showing the ingress of shadow of Satellite No. 3 to some visiting parties and found the satellite on its central meridian passage as a dusky reddish spot below the southern belt.

On ingress of the shadow when compared with that of the satellite its prominence was estimated as five to one. The dusky image and its following shadow presented a charming picture in their transit westward across the Jovian disk.



Satellite No. 3 on Central Meridian 6h 04m P. M. | Ingress of Shadow 6h 12m P. M. | Egress of Satellite 7h 40m P. M.

DARK TRANSIT OF JUPITER'S THIRD SATELLITE.

Upon the emergence of the satellite it appeared full and round and of a dull red color on the background of the clear sky.

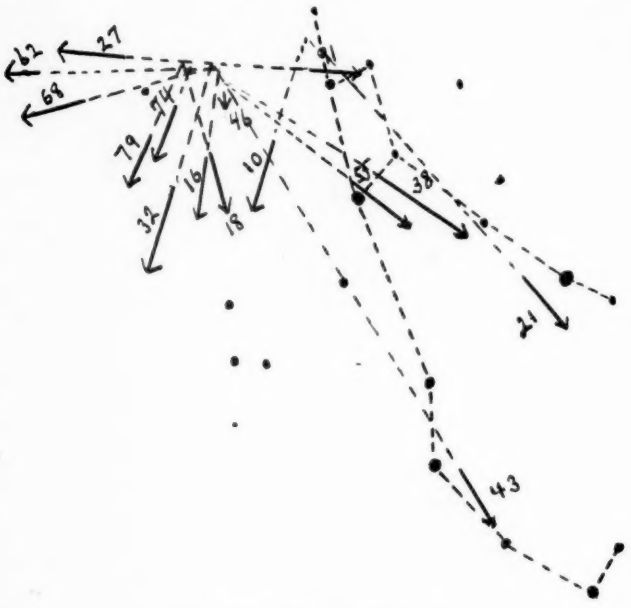
Although Jupiter has reached nearly the southern limit of his heliocentric latitude and the shadow-cone of the satellite was projected more than 670,000 miles yet it traversed almost directly the path of the preceding satellite, thus presenting a striking illustration of the near coincidence of Jupiter's orbit with the plane of the ecliptic.

WILLIS L. BARNES.

CHARLESTOWN, Ind.

The Perseids, August 12.—The Perseids were not as numerous as in 1902. Perhaps the moonlight had something to do with it, but there were not as many bright ones this year; 111 were observed on August 20 between $11^h\ 22^m$ and $3^h\ 44^m$; in 1902 over 300 were observed in about the same time.

July 27		2	Perseids		Aug. 13	1:20-1:40	10	Perseids
Aug. 12	7:30-11:30	4	"	Cloudy.		1:40-2:00	5	"
	11:20-11:40	6	"			2:00-2:20	11	"
	11:40-12:00	8	"			2:20-2:40	0	"
	12:00-12:20	4	"			2:40-3:00	16	"
	12:20-12:40	7	"			3:00-3:44	31	"
	12:40- 1:00	6	"					
13	1:00- 1:20	9	"				119	Perseids



PERSEIDS, AUGUST 12, 1903.

The average was about 29 an hour, the maximum being reached between 2:40 and 3:40. They were often brilliant, and very swift. Some of the brightest observed

11:26	— 2	G, was equal to Jupiter in brilliancy.
11:28	— 4	G, burst over the ocean with a beautiful green light.
11:52	— 3	W
11:55	— 4	Orange, left a magnificent green trail.
1:05	— 3	W, left a long white trail.
2:49	— 2	Orange.
2:49	— 2	Orange.

Towards sunrise there were sometimes several a minute, and between 3:02 and

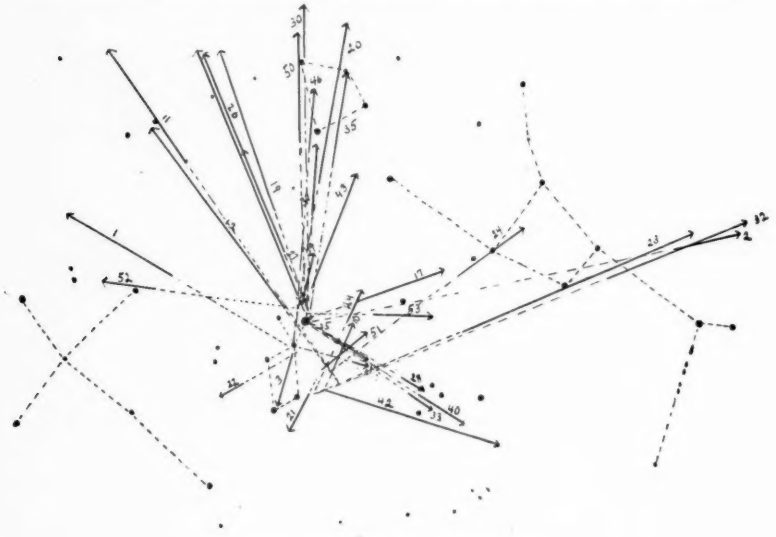
3:44, although the sunrise light was very bright 31 were counted, some rivalling Jupiter and Venus in brightness. For a number of evenings after August 12 very bright ones would go clear across the sky in the early evening. There seemed to be two radiants, one very near γ Persei, and another N. W. of γ perhaps two or three degrees.

The Lyrids, April 18, 19 and 20, 1903.

Number.	Time.	Mag.	Color	Trails.	Remarks.
1	11:28	0	W		April 18.
2	11:28	2	W		April 19.
3	11:36	4	W		
4	11:40	5	W		
5	11:48	2	W		
6	11:56	4	W		
7	11:59	5	W		
8	1:01	5	W		
9	1:04	5	W		11 shooting stars were also seen.
10	12:06	2	W	5W	
11	12:13	3	W		Very swift.
12	12:13	3	W		" "
13	12:18	2	W		
14	12:24	3	W		
15	12:26	5	W		
16	12:28	3	W		
17	12:47	4	W		
18	12:48	3	W		
19	12:52	4	W		
20	12:53	1	W, R		9 shooting stars observed.
21	1:05	1	W	4W	
22	1:05	3	W		
23	1:06	0	W	3W	
24	1:09	2	O		
25	1:12	6	W		
26	1:13	0	W	4W	
27	1:15	6	W		
28	1:18	2	B, W	3W	
29	1:24	4	W		
30	1:27	−1	R	5W	
31	1:33	−1	B		
32	1:43	2	W	5W	
33	1:44	2	W	5W	
34	1:45	0	R		
35	2:00	2	W		
36	2:05	4	W		
37	2:05	−1	W		Like a white flash.
38	2:06	4	W		
39	2:10	4	W		
40	2:12	2	R		
41	2:17	2	R		
42	2:20	4	B		
43	2:21	4	W		
44	2:30	3	B		
45	2:39	0	R		
46	2:40	3	W		
47	2:40	4	W		
48	2:40	5	W		
49	2:51	5	W		
50	2:51	5	W		
51	2:54	4	R		
52	2:55	4	W		
53	2:51	1	R		

April 20 was a beautiful night for observing meteors. The air was clear and

cool. The Lyrids were not very numerous, but seemed to come in bunches. There were intervals of ten and fifteen minutes when none were observed. Forty-four observed between 12:06 and 2:57, 9 were observed on April 18 and



LYRIDS, APRIL 18, 19, AND 20, 1903.

19, and 20 shooting stars were seen. The Lyrids were very swift and sometimes bright. The radiant was not sharply defined. There seemed to be three; the largest near Vega (α Lyræ), and one near ζ and β. ROBERT M. DOLE.

JAMAICA PLAIN, Mass.

The Mounting of Fixed Meridian Instruments.—Professor G. W. Hough, director of Dearborn Observatory, Evanston, Ill., published in number 3902 of the *Astronomische Nachrichten*, an extended article on the determination of the cause of variation of level and azimuth in fixed meridian instruments. Professor Hough's long and varied experience with the meridian instrument enables him to speak with authority concerning the construction and mounting of such an instrument. His experience at Albany, Chicago and Evanston together with the knowledge gained by the experience of other astronomers in many different observatories, has enabled him to bring together in this article, above referred to, a variety of useful information that seems to us unique and unparalleled.

Attention was first drawn to this matter by the behavior of the Repsold meridian circle at Washington, in the United States Naval Observatory, which was mounted on white marble piers. "It is well known to astronomers that this instrument was subject to large variation in azimuth. About a year ago a writer in *Science* said it acted like a good thermometer;" and Professor Hough remarks that such action appeared to him to be "a very excellent quality in any meridian instrument provided the scale was sufficiently short."

Some of the astronomers in charge of the Washington circle were not satisfied with the mounting of the instrument because of these changes in azimuth, and the marble piers were removed and brick ones put in the place of them. The marble piers had a coëfficient of temperature, but Professor Hough says he is informed that the brick piers have no coëfficient of temperature, and that he is unable to agree with the statement in regard to brick piers for several reasons, one of which is, he had himself, in recent years, taken a Repsold meridian circle from brick piers and placed it on stone piers.

Speaking of the various causes that effect the level and the azimuth, Professor Hough notices the opinions of some observers regarding the temperature effect on the ground which is the site for the observatory. Some have thought that if the site is a hill, the heating of the east side more than the west in the forenoon would affect the errors one way, and contrary-wise in the afternoon. But the cause of change does not seem to lie in this direction, because from thermometers sunk in the rock at Edinburgh to the depth of 6 feet in 1836, it was found that the mean annual curve for level was of the same form as that given by the thermometer, but that the diurnal change of temperature was not followed. It did seem to be true that the whole hill was elevated by the change of temperature registered but not in the way anticipated by diurnal effects.

The records kept at Edinburgh and Greenwich do show a change of temperature at different depths below the surface of the ground. The greatest difference of change for any two consecutive days during a year at different depths is shown by the following table:

Depth Below the Surface.	
25 feet	± 0°.05 F.
12 "	± 0°.10
6 "	± 0°.20

Following this table Professor Hough gives a brief run of how different meridian instruments with different mountings have behaved from 1851 to the present time.

He then attacks the problem of the action of changes of temperature on some of the physical constants, such as conductivity and expansion. If the conductivity of heat for iron is taken as unity the following values are known:

Iron	1
Mercury	0.1
Stone or brick	0.007
Wood	0.006

In the case of expansion, if iron be assumed as one, the following table shows the relative expansion of other substances used in connection with the meridian instrument:

Iron	1
Brass	1.6
Sandstone, granite, etc	0.8 to 0.9
Brick	0.3 to 0.5

The level and azimuth errors of the Dearborn meridian circle for the year 1901 and 1902 graphically represented make an instructive study, and the final graph showing the predicted and the observed changes gives the two curves as agreeing rather remarkably well.

When the new observatory at Evanston was being erected the meridian circle

was housed "in a temporary building one half mile from its present site. It was mounted on brick piers, and the iron lugs were set in the piers with plaster of Paris. The level was determined by nadir observations:"

MONTHLY RANGE OF LEVEL.

	Stone.	Brick.
	"	"
I	1.4	3.1
II	1.7	7.6
III	1.5	3.0
IV	0.4	3.2
V	0.6	6.2
VI	4.1	4.9
VII	0.9	3.5
VIII	3.6	6.8
IX	2.7	3.0
X	0.7	4.4
XI	2.0	4.7
XII	2.8	1.8
Mean	1.9	4.4

"While the instrument when on brick piers had no temperature coëfficient for level yet the average was more than twice as great as when on stone piers."

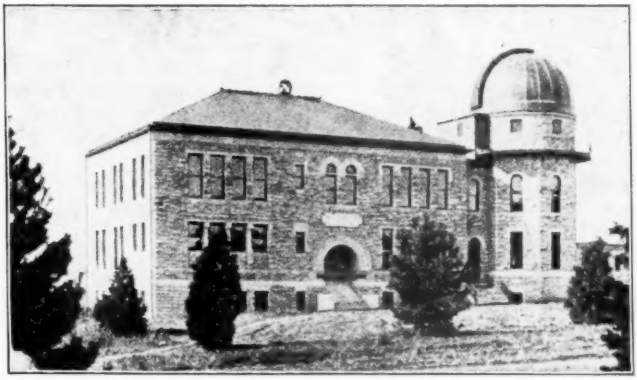
The following table gives the 'mean' monthly range during a year in azimuth and level for a few well known instruments mounted on brick and stone piers respectively:

MEAN MONTHLY RANGE FOR AZIMUTH AND LEVEL.

Instrument.	*a.*	*b.*	Pier.	Date.
	"	"		
Chicago	6.5	7.8	Brick	1883
Evanston	7.6	4.4	"	1888
Madison	1.3	5.1	"	1885
Poulkova	7.9	3.9	"	1845
Lick	3.3	2.0	"	1895
Evanston	4.1	1.9	Stone	1901
Greenwich	3.5	2.7	"	1879
Cape	2.4	2.1	"	1896
Washington (9-inch)	7.9	1.9	"	1868

The Rotation Time of Venus.—We notice on page 236 of No. 48 *Astronomische Rundschau* that the editor questions Mr. Slipher's conclusions in regard to the rotation time of the planet Venus in recent spectroscopic observations made at Lowell Observatory, Flagstaff, Arizona. Mr. Slipher's position is that he does not find an inclination of lines showing recession and approach of the opposite limbs of the planet, as should be if the planet had a period of rotation of about 24 hours. He is criticised because his argument is negative; his critic saying that 1000 negatives will not overthrow one positive. That kind of criticism is sound in some things, but certainly not in this case. An astronomer should know that one spectroscopic negative proof in this case is just as good as a spectroscopic positive one. The spectroscope defines motion and the lack of it in the same way, by inclination of lines or the lack of it.

Astronomical Observatory at Washburn College.—The Astronomical Observatory at Washburn College, Topeka, Kansas was dedicated, Friday, September 18, 1903 at 3 o'clock, the exercises being held on the college



OBSERVATORY AT WASHBURN COLLEGE, TOPEKA, KANSAS.

campus, Professor Charles L. Doolittle of the University of Pennsylvania giving the principal address on that occasion.

The address is printed in full in this number of POPULAR ASTRONOMY.

Comet *c*, 1903 Borrelly—The plate at the beginning of this number was made from two fine photographs of Comet *c* (Borrelly) taken at the Observatory of Yale University by M. F. Smith who favored us with glass positives and platinum prints. The dates of the exposures were July 24 and July 27. We were pleased to get these photographs because we did not secure any at that time at Goodsell Observatory, nor had we seen any from other sources. These photographs were received in time for our October number and would have appeared in that issue if the engravers had not failed to reproduce them in satisfactory way.

The October number of the *Astrophysical Journal* contains an article by E. E. Barnard giving the photographic observations of the comet and explanation of the phenomenon of the tail on July 24, with illustration reproduced from his and other photographs. His illustrations are very clear and neatly definite, and show some more of detail than we have been able to get, although our copy was first rate and two trials were made by different engravers to reproduce them.

The conditions of the tail of Borrelly's comet on July 24 was simply wonderful. We regret that Mr. Smith of Yale did not give us the hours of the days on which the exposures were made. The length of exposure at Yale Observatory on July 24 was 4 hours, but we do not know at what time in the night it was made. The Yerkes Observatory photographs were taken on July 24, one at $14^h\ 57^m$ to $17^h\ 34^m$ and another at $17^h\ 59^m$ to $20^h\ 29^m$. At the first exposure the break in the tail was about one-fourth of the way from the head outward towards the end. The second exposure showed that the division had moved apparently at considerable velocity outward from the comet's head and in the general direction of the tail. This was not only apparently true, but the

separation of the two parts of the tail was also a feature of great surprise. From measures and computations made by Mr. Barnard, the rate of separation was 29 miles per second. At this time the comet was approaching the Sun at the rate of 22 miles per second, the remaining 7 miles per second would be the actual velocity of the particles of which the tail is composed.

It is not easy to decide, from the few facts at hand, what causes underlie the rapid physical change which the tail of the comet underwent during the night of July 24. Mr. Barnard thinks from the preliminary study given to it, so far, that it may have been caused by a cessation for a brief time of the outward flow of the particles forming the train; or that, from some cause, the direction of the repellant force from the Sun may have changed.

Theoretically either of these causes would produce a break in the tail, but, in the former case it would not seem probable that one portion would overlap the other to so great a distance if the entire cessation of the repellant solar energy were the chief cause. The second suggestion seems to us the stronger one.

Mr. Barnard refers in this article to a happy suggestion of Mr. Wallace of the Yerkes Observatory. That of taking one of his own photographs and one of Mr. Barnard's and placing them side by side so as to use them with the stereoscope. The dates of the pictures so used were July 22, $15^h\ 0^m$ to $17^h\ 30^m$ G. M. T. and July 22, $18^h\ 1^m$ to $20^h\ 31^m$ G. M. T. The effect of the stereoscopic view is to make the comet stand out from the stars, as if hanging in the sky wholly independent of them in beautiful and impressive relief.

Shall the Coast Survey be Dismembered?—The proposition to turn the hydrographic work of the Coast Survey over to the Navy Department has been so long urged and so often rejected that its revival at the present moment seems singularly inopportune. Twice at least within the last twenty years it has been exhaustively considered and adversely reported on by committees of Congress when all the circumstances were much more in in its favor than they are at present. Prominent treasury officials under the first administration of President Cleveland were known to be so hostile to the management of the survey that an investigation not only unfriendly, but very far from judicial in its character, was undertaken with the approval of the President. The report set forth that abuses had crept into the management, some of them of long standing. The resignation of the superintendent was forced, and it only remained for Congress to take the necessary action to transfer the survey. At the following session a committee of Congress, having Senator Allison at its head, made a thorough investigation of the whole subject. The result of this inquiry was to leave things as they were.

The effort to effect the transfer was renewed with great vigor in 1893. A majority of the naval committee was believed to favor the change, several of its members being warm advocates of the measure. But, after a careful hearing of all that was to be said on both sides, the committee reached a conclusion adverse to the transfer. What has happened since to lead to a change? Nothing whatever. On the contrary, the establishment of the Department of Commerce with the Coast Survey as one of its bureaus removes the last reason for considering the subject, No work is more appropriate to the Department of Commerce than that of providing facilities for navigating our coasts. Charts and soundings are of the first importance not only to our coasting ships and our entire mercantile marine, but to all ships from abroad which enter our ports. Of course, a naval ship has as much need as a merchantman for these means of navi-

gation. There is nothing required on a chart for naval use different from that required for the ordinary purposes of commerce. Accordingly, the Coast Survey was very naturally included among the bureaus to be transferred to the new department.

Extraordinary though the proposition to reverse the action may now appear, the reasons against it are so strong and so near the surface that they hardly need to be cited if the question is to be decided on its merits. Looking at the matter from a purely abstract point of view, the question is whether such a work as that of making charts of our coast can be most efficiently and economically undertaken by the navy or by a civilian organization like the present one. Let us carefully weigh all that is said in favor of the proposed transfer. Hydrographic surveying is part of the business of a naval officer. He learns as much about it while at the Naval Academy as the absorbing character of his other duties will permit. The question whether, during the limited periods which he can possibly devote to such work, he can acquire as much skill as a civilian wholly engaged upon it, is a question which the reader can decide for himself. But the mere fact that the naval officers can do the work does not prove that it should be placed under the Navy Department rather than under that of commerce. The arguments on the question whether naval or civilian methods are the more economical have, on the whole, been favorable to the civilians. But even here one important item has been too little considered, and that is the cost of the naval officer himself. The mere salary of the latter is but a part of what it costs the government to educate and train him. In estimating his cost, we must include not only what is expended in his training and his off-duty pay, but his retired pay also. To reach a correct conclusion on this point, we shall probably have to double the pay of every officer of the navy from the time when he gets his first commission up to the date of his retirement. Of course, we must include in the estimate the millions being expended at the Naval Academy for the improvement of its facilities. To expend such sums in training officers to perform duty that civilians are now carrying on at far less cost would be a most unjustifiable expenditure of the public money.

The slight reason for the employment of naval officers on civil duty which formerly existed has entirely disappeared with the lapse of time. For several years after the civil war we had more officers than were necessary for the management of our ships and the administration of shore stations. Under these circumstances there was no objection to their employment on such outside service as might be appropriate. But all this has now been changed. The cry in every department of the naval service is for more officers. We hear daily stories of the department's inability to man its ships properly. Why should the service be deprived of its trained officers if this is the case?

The practice of foreign nations has been cited in favor of the proposed action. It is true that the hydrographic surveys of the leading countries of Europe are carried on to a large extent by their respective naval departments. But this statement needs to be supplemented by two others. Both the administration and the personnel of foreign surveys are to a greater or less extent distinct from those which relate to naval duty properly so called. In France the surveys are all conducted by a special corps of 'hydrographic engineers,' and not by line officers at all. In England, by custom, the hydrograher of the admiralty is permanently withdrawn from military duty. He can, of course, be restored to it if such a course is desirable, but practically this is seldom, if ever, done.

These features of foreign hydrographic surveys have always been success-

fully antagonized by our naval authorities, and we cannot suppose that they have changed their minds on the subject. The transfer of the Coast Survey to the Navy Department, whatever may be the intentions of those who favor it, practically means the administ ation of the survey and the performance of its most difficult work by officers of the navy, each temporarily withdrawn from naval service proper for this special duty, which he is expected to abandon for life about the time when he has obtained a respectable measure of skill in its performance. A civilian organization under the Secretary of the Navy, however plausible it may be made to appear, is an impossibility in the present state of naval opinion.

The law organizing the Department of Commerce gave the President authority to transfer to it bureaus from other departments of the government, that of the navy included. There is good reason to believe that this provision was expected to lead to the inclusion of the National Observatory, and perhaps of the Hydrographic Office also, within the new department. The transfer of the former is loudly called for by all the facts of its history and present position, and if any unification of the government hydrographic surveys is to be carried out, it should be done by transferring the Hydrographic Office also, for it has no necessary relation to the Navy Department whatsoever, and properly belongs to the Department of Commerce.—New York *Evening Post*, September 23, 1903.

Meteorites or Aerolites.—By a slip of the pen (as I think the context sufficiently shows) I described Mr. Denning (p. 359) as holding that we overtook the majority of fireballs instead of holding that the majority of fireballs overtook us. The point on which I was insisting (in which Mr. Denning agrees with me) is that the majority of fireballs were moving in the same direction as the Earth instead of meeting us when coming from the opposite direction as the majority of meteors do. But in most instances if not all the fireball seems to be moving faster than the Earth and overtakes us instead of being overtaken.

The misprints of "trainline" for "tramline" and "Zorkshire" for "Yorkshire" scarcely need correction. W. H. S. MONCK.

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